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15/ENG07/031

PETROLEUM ENGINEERING

CHE574 ASSIGNMENT

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

b. Distinguish between the sustainable energy and resources and non-sustainable energy and resources

c. 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.

QUESTION 1

A. The Various Forms Of Energy

Although there are several types of energy, scientists can group them into two main categories: kinetic energy and potential energy.

i. Kinetic Energy

Kinetic energy is energy of motion. Atoms and their components are in motion, so all matter possesses kinetic energy. On a larger scale, any object in motion has kinetic energy. A common formula for kinetic energy is for a moving mass:

$$KE = 1/2\ mv^2 \ldots\ldots (1)$$

KE is kinetic energy, m is mass, and v is velocity. A typical unit for kinetic energy is the joule.

ii. Potential Energy

Potential energy is energy that matter gains from its arrangement or position. The object has the ‘potential’ to do work. Examples of potential energy include a sled at the top of a hill or a pendulum at the top of its swing. One of the most common equations for potential energy that can be used to determine the energy of an object with respect to its height above a base:

$$E = mgh \ldots\ldots (2)$$

PE is potential energy, m is mass, g is acceleration due to gravity, and h is height. A common unit of potential energy is the joule (J). Because potential energy reflects the position of an object, it can have a negative sign. Whether it is positive or negative depends on whether work is done *by* the system or *on* the system.

Other Types of Energy

While classical mechanics classifies all energy as either kinetic or potential, there are other forms of energy. The other forms of energy include:

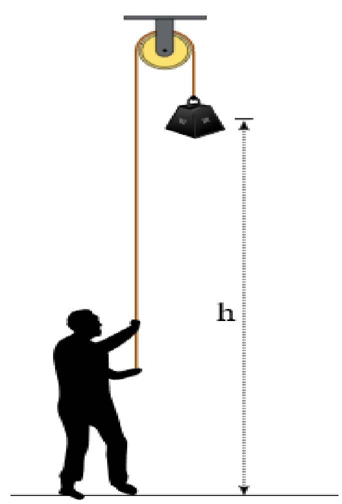
i. Gravitational energy

This is the energy resulting from the attraction of two masses to each other. All conservative forces have potential energy associated with them. The force of gravity is no exception. Gravitational potential energy is usually given the symbol Ug. It represents the potential an object has to do work as a result of being located at a particular position in a gravitational field.

Consider an object of mass m, being lifted through a height h, against the force of gravity as shown below. The object is lifted vertically by a pulley and rope, so the force due to lifting the box and the force due to gravity, Fg, are parallel. If g is the magnitude of the gravitational acceleration, we can find the work done by the force on the weight by multiplying the magnitude of the force of gravity, Fg, times the vertical distance, h, it has moved through. This assumes the gravitational acceleration is constant over the height h.

Gravitational potential energy is expressed as: $U_g = F_g \cdot h$

$$= m \cdot g \cdot h \quad \ldots\ldots (3)$$



A weight lifted vertically to acquire gravitational potential energy

ii. Electric energy

This is energy from a static or moving electrical charge. The calculation of energy in electrical systems depends on the amount of current flowing through a conductor (I) in amperes, as well as on the electrical potential, or voltage (V), driving the current, in volts. Multiplying these two parameters gives the power of the electricity (P) in watts, and multiplying P by the time during which the electricity flows (t) in seconds gives the amount of electrical energy in the system, in joules.

The mathematical expression for electrical energy in a conducting circuit is:

$$E(e) = P \times t = V \times I \times t \quad \ldots\ldots..(4)$$

iii. Magnetic Energy

This is energy from the attraction of opposite magnetic fields, repulsion of like fields, or from an associated electric field. When an object or body is characterized by polar movement, i.e., the existence of two poles, which have exactly opposite characteristics, then the entity that controls all the related processes is called magnetic energy. The force that is exerted is in the form of a magnetic field, and the North and South poles of this field are situated exactly opposite to each other. A popular example is that of our planet, the Earth, which behaves like a giant magnet. The magnetic energy travels in the form of magnetic lines, which extend from the North to the South Pole, creating the magnetic field.

iv. Nuclear Energy

This is the energy from the strong force that bonds protons and neutrons in an atomic nucleus. Nuclear energy is the energy that is trapped inside each atom. It is a type of potential energy, and it is mainly derived from processes involving nuclear fission and nuclear fusion. In the former one, a radioactive elemental atom is divided or separated, further giving rise to daughter elements, and releasing a tremendous amount of energy. This principle is used in case of nuclear reactor and other associated technological applications. In the latter type, two atoms of an element combine with each other and fuse. The fission process is the widely used method. This process also leads to the release of high amount of energy, and the prime example where this process is said to occur is that of the Sun; it is theorized that in this star, nuclear fusion is taking place at its core portions.

v. Thermal Energy

This is also called heat, this is energy that can be measured as temperature. It reflects the kinetic energy of atoms and molecules. *Thermal energy* refers to the energy contained within a system that is responsible for its temperature. Heat is the flow of thermal energy. Almost every transfer of energy that takes place in real-world physical systems does so with efficiency less than 100% and results in some thermal energy. This energy is usually in the form of *low-level* thermal energy. Here, low-level means that the temperature associated with the thermal energy is close to that of the environment. It is only possible to extract work when there is a temperature difference, so low-level thermal energy represents 'the end of the road' of energy transfer. No further useful work is possible; the energy is now 'lost to the environment'. Thermal energy can be easily represented in the form of an equation that describes a mono-atomic gas in the following manner:

$$K = (M \times V2) \div 2 \ldots\ldots (5)$$

Thus, if a gas has 'N' molecules, then its thermal energy can be represented as.

$$U = (N \times M \times V^2) \div 2 \ldots. (6)$$

$$U = (N \times kT) \div 2 \ldots. (7)$$

Where, 'k' is the Boltzmann constant, and 'T' is the measured temperature or the heat of the body. From the above formula, it is clear that this energy operates by the processes of absorption or emission of heat, during its transfer from one portion of the system to another.

vi. Chemical Energy

This is the energy which is stored in the bonds of chemical compounds (molecules and atoms). It is released in the chemical reaction and mostly produces heat as a by-product, known as an **exothermic reaction.** The examples of stored chemical energy are biomass, batteries, natural gas, petroleum, and coal. Mostly, when the chemical energy is released from a substance, it is transformed into a new substance completely. This type of energy is often represented in the form of the Rydberg constant, which is given as:

$$R\infty = (Me \times E4) \div 8eo2H3C \ldots\ldots (8)$$

$$R\infty = 1.097 \times 107 \times m^{-1} \text{ …….. (9)}$$

'Me' is the mass at zero motion, 'E' is the charge, 'eo' is the space permittivity, 'H' is the Planck constant, and 'C' is the light speed.

vii. Mechanical Energy

Mechanical energy is the energy a substance or system has because of its motion. For example machines use mechanical energy to do work. It is basically defined as the summation of potential and kinetic energies of a body, which is affected by external forces. If the body is not affected by any external force, then the mechanical energy 'Me' remains constant, i.e., the body is isolated from any external forces. This is a hypothetical scenario, and in reality, forces like friction act on all bodies, though their values are very less. Thus, this energy can be simply represented as:

$$Me = Ep + K \text{ …….. (10)}$$

Where, 'Ep' is the total potential energy, and 'K' is the kinetic energy. Numerous modern devices convert other forms into mechanical energy and vice-versa, like thermal power plants (heat to Me), electric generators (Me to electricity), turbine (Kinetic energy to Me), etc.

viii. Radiant Energy

This is the energy from electromagnetic radiation, including visible light and x-rays (for example). It is propagated by electromagnetic waves through space; for example, the light received from the Sun is an example of radiant energy. The spectrum of electromagnetic radiation is vast—from radio waves to the high-frequency gamma rays. The energy derived from this source is directly proportional to the frequency of waves. Humans can only detect the visible light spectrum of electromagnetic radiation, and all other wavelengths are invisible. Majority of light energy that is received by our planet is in the form of the Sun's rays

B. Sustainable Energy And Resources & Non-Sustainable Energy And Resources

i. **Sustainable Energy:** An energy source can be considered as sustainable if it fulfills 3 demands of energy.

- The energy can be naturally replenished.
- Technology should improve energy efficiency.
- The long term availability

Sustainable Energy is one which is able to meet the growing demand of today's people without compromising the demand of the people that would require it in future. Sustainable energy can also be defined as energy sources that are not expected to be depleted in a time frame relevant to the human race; therefore they contribute to the sustainability of all species. All renewable energy sources like solar, wind, geothermal, hydropower, wave and tidal power are forms of sustainable energy. These energy sources have been here since centuries and are here to stay till life is available on earth. Renewable energy sources have low environmental impact, widely available and are naturally replenished.

Renewable energy includes all those sources that do not cause any harm to environment and have minimal impact on the surrounding environment. Sustainable is much more a wider term and includes all type of energy sources. Sources such as solar, wind, geothermal, hydropower, wave, tidal and hydrogen are renewable as well as sustainable since they have minimum impact on the environment whereas Nuclear energy or nuclear power is not considered as renewable but it is sustainable as it pollutes the environment. This is the only reason that it is said that all renewable energy sources are sustainable but all sustainable energy sources are not renewable.

ii. **Non-Sustainable Energy and Resources** (Non-renewable Energy)

Nonrenewable resources are resources that have a limited supply. More than that, these resources can't be replaced by natural means at a pace that meets its consumption. A lot of our fossil fuels, such as oil, are nonrenewable resources. Non-renewable energy is a **source of energy that will eventually run out**. Most sources of non-renewable energy are fossil fuels, such as coal, gas and oil. These natural resources are a major source of power for a vast amount of industries however, there are **numerous downsides** to non-renewable energy, including their **negative environmental impact** and the fact they are in **limited supply.**

In many of the examples of nonrenewable resources, the supply comes from the Earth itself. However, since it typically takes millions of years to develop, these resources are finite. Nonrenewable energy can generally be separated into two main categories: fossil fuels and nuclear fuels.

C. The Typical Energy Resource Mix for Sustainable Energy Development

Renewable technologies with exception to traditional biomass are often termed 'modern renewables'. These include hydropower, solar, wind, geothermal and modern biofuel production (including modern forms of waste-to-biomass conversion). The change & mix of modern renewable consumption over the last 50 years is shown in the chart. This is measured in terawatt-hours per year and can be viewed across a range of countries and regions.

Globally, the world produced approximately 5.9 TWh of modern renewable energy in 2016. This represents a 5 to 6-fold increase since the 1960s. Here we see that hydropower remains the dominant form of modern renewables consumption, accounting for almost 70 percent. Despite absolute growth in production, hydropower's share is, however, declining as other renewable technologies grow.

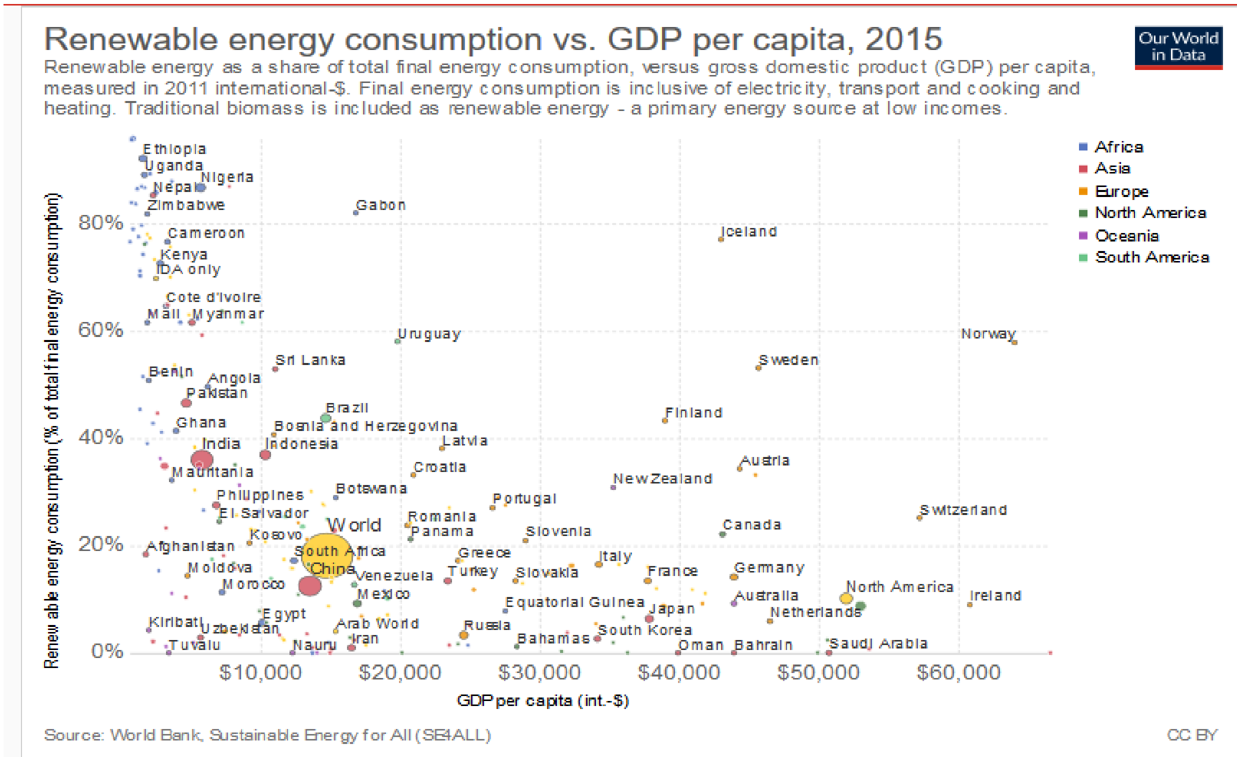


Fig 1: Renewable Energy Consumption vs. GDP per Capita

The chart shows the share of final energy consumption (which is inclusive of electricity, transport, heating and cooking) derived from renewables plotted against income (GDP per capita, adjusted for cross-country price differences).

Here we see that at very low incomes, the majority of final energy is derived from renewables, this is predominantly in the form of traditional biomass for cooking and heating. With increasing incomes, we see that countries tend to shift towards more fossil-fuel based energy sources: this represents the transition from traditional biomass towards solid fuels for cooking and increasing electricity access. Continued economic development through low-to-middle and into higher incomes has historically been achieved for most countries through industrialisation, and as a result a dominance of fossil fuels within the energy mix. This is shown by the continued decline in renewables as a share of final energy.

As countries approach upper middle to high-incomes, we tend to see a trough in this trend as investment in renewables increases and the share begins to rise again. This progress is much more noticeable for some countries than others: Denmark, Austria and Sweden, for example, show this bottom plateau then rising trend clearly. Others, such as Canada, the United States and Australia show much flatter trends. This shape of trend is somewhat relatable to the inverse Kuznet's Curve: renewable share falls with increasing income before reaching a turning point where it begins to rise again.

The Nigerian Environment

According to the statistics from the International Energy Agency (IEA), total Nigerian primary energy supply was 118,325 Kilotonne of Oil Equivalent (ktoe) excluding electricity trade in 2011. As depicted in the figure below, biomass and waste dominated with 82.2%. Renewable energy sources only accounted for a small share of the energy supply. For instance hydropower only accounted for 0.4%. Wind and solar are also utilized, but at an insignificant level at present.

Also according to the chart below, Biomass is the dominant energy source in Nigeria due to the huge reliance on the energy source for cooking and heating purposes by majority of the Nigerian people.

In my own view, wind turbines for water pumping should be installed in some parts of the country for testing and subsequent use in the country. Hydropower projects should be taken up mainly for electrification. Nigeria as a country is a mix of citizens with low-to-middle and also upper middle to high-incomes. Continued economic development in Nigeria will occur through industrialization as investment in renewables increases and dominance of fossil fuels within the energy mix declines.

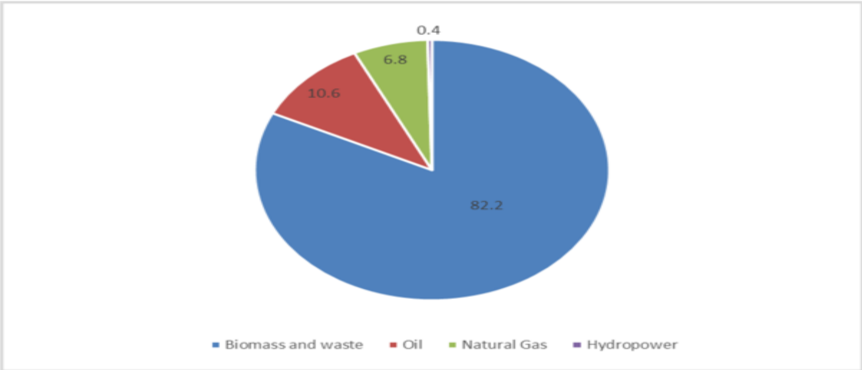


Figure 2: Energy supply by source in 2011 (in %)

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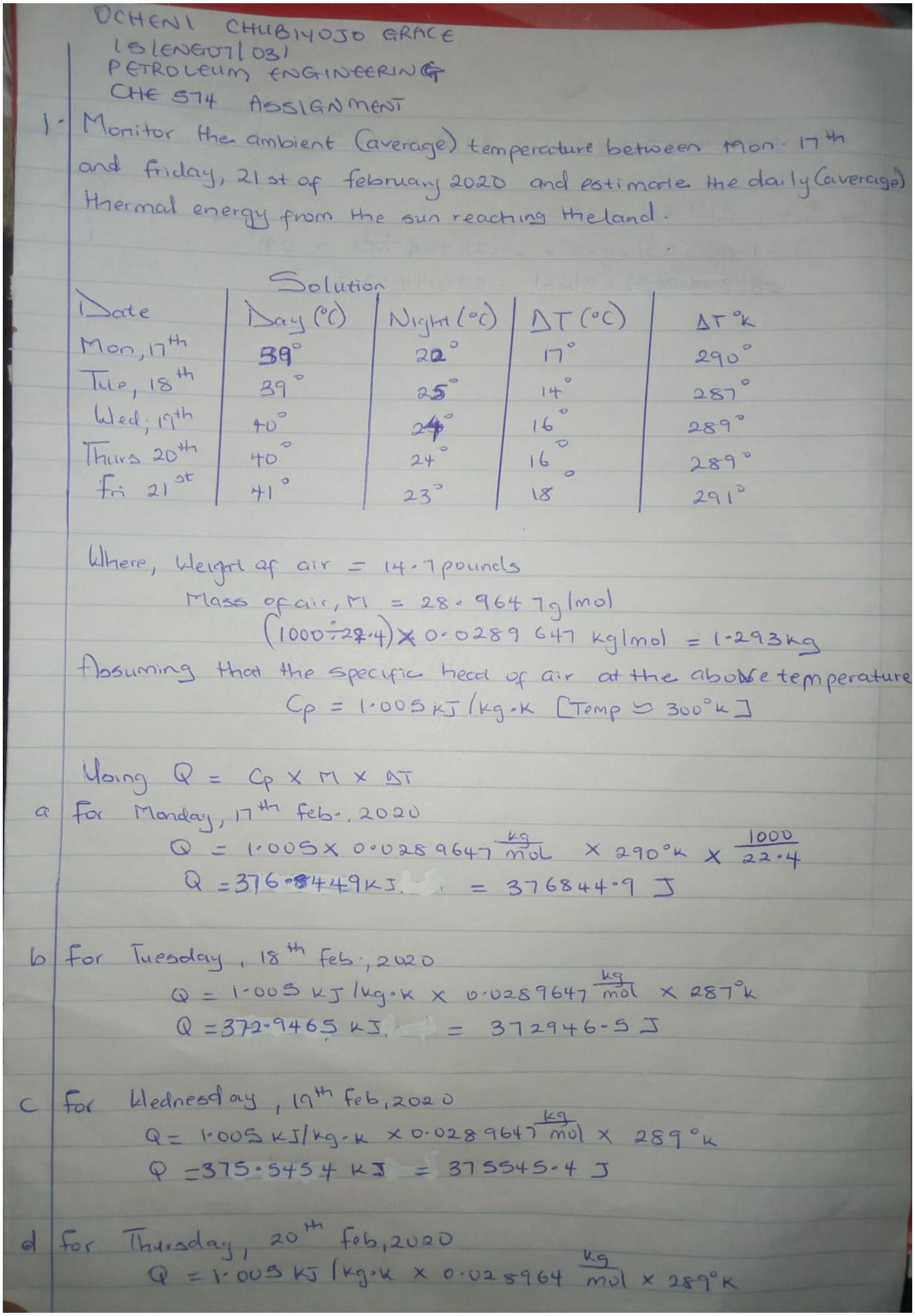
QUESTION 2



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1. Monitor the ambient (average) temperature between Mon. 17th and friday, 21st of february 2020 and estimate the daily (average) thermal energy from the sun reaching the land.

Solution

Date	Day (°C)	Night (°C)	ΔT (°C)	ΔT °K
Mon, 17th	39°	22°	17°	290°
Tue, 18th	39°	25°	14°	287°
Wed, 19th	40°	24°	16°	289°
Thurs 20th	40°	24°	16°	289°
Fri 21st	41°	23°	18	291°

Where, Weight of air = 14.7 pounds

Mass of air, M = 28.9647 g/mol

$(1000 \div 22.4) \times 0.0289647$ kg/mol = 1.293 kg

Assuming that the specific heat of air at the above temperature

$C_p = 1.005$ kJ/kg.K [Temp ≅ 300°K]

Using $Q = C_p \times M \times \Delta T$

a For Monday, 17th feb., 2020

$Q = 1.005 \times 0.0289647 \frac{kg}{mol} \times 290°K \times \frac{1000}{22.4}$

Q = 376.8449 kJ = 376844.9 J

b For Tuesday, 18th Feb., 2020

$Q = 1.005$ kJ/kg.K $\times 0.0289647 \frac{kg}{mol} \times 287°K$

Q = 372.9465 kJ = 372946.5 J

c For Wednesday, 19th Feb, 2020

$Q = 1.005$ kJ/kg.K $\times 0.0289647 \frac{kg}{mol} \times 289°K$

Q = 375.5454 kJ = 375545.4 J

d For Thursday, 20th Feb, 2020

$Q = 1.005$ kJ/kg.K $\times 0.028964 \frac{kg}{mol} \times 289°K$

$Q = 375.54539\ kJ = 375545.4\ J$

e) For Friday, 21st Febr, 2020

$Q = 1.005\ kJ/kg \cdot K \times 0.028964\ \frac{kg}{mol} \times 291°$

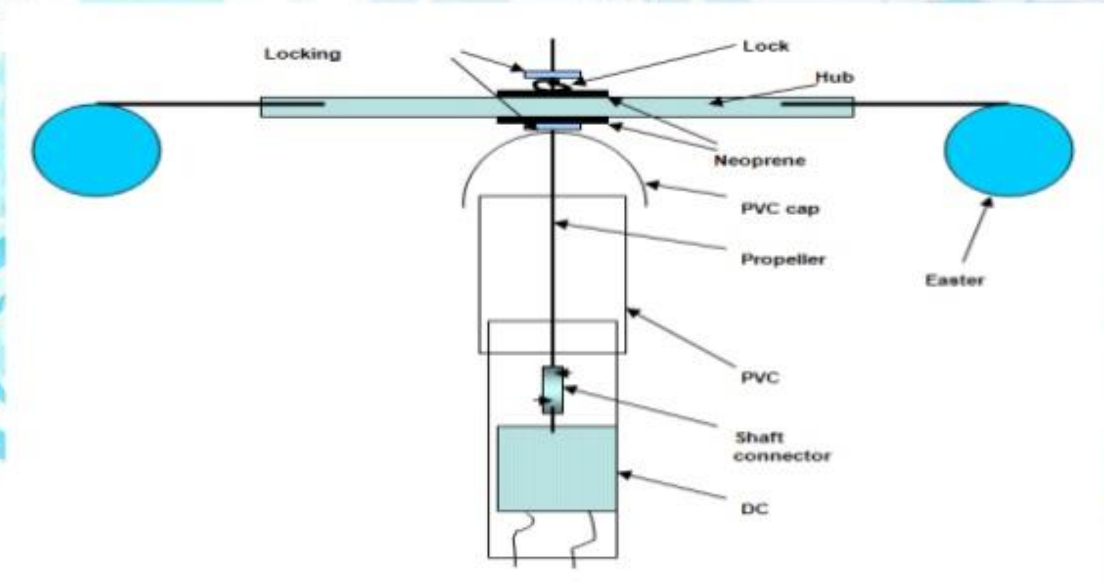
$= 378.14432\ kJ = 378144.3\ J$

The average thermal energy, Q_{avg} =

$$\frac{376844.9 + 372946.5 + 375545.4 + 375545.4 + 378144.3}{5}$$

$Q_{avg} = 375805.3\ J$

BASIC PARTS OF ANEMOMETER



QUESTION 3

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

Dams are constructed to serve various purposes such as water supply, flood control and power generation. A dam is a barrier constructed to hold back water and raise its' levels, forming a reservoir, used to generate electricity or as water supply. A dam may be natural but most are man-made and in Nigeria, we have some very useful man-made dams. There are three functional dams in Nigeria which are the Kainji, Jebba and Shiroro Dams[1].

- **Kainji Dam** is arguably the most important dam in Nigeria situated in Niger State. The dam sits across River Niger and is responsible for the buildup of the Kainji lake, a water reservoir. It was built mainly to generate hydroelectricity and it helps to power all major cities in Nigeria.
- **Jebba Dam** is another very important dam in Nigeria and it is situated in Jebba town, a town which cuts across Kwara state and Niger state respectively. The Jebba dam is a hydroelectric dam and it contributes significantly to the Nigerian National grid. Jebba dam operates by using the great power of the River Niger to generate copious amounts of electricity for Nigeria.
- **Shiroro Dam** rests on the Kaduna River in Niger state. It began operations in 1990 and it contributes significantly to the power supply in Nigeria.

  Most large hydroelectric power plants generate electricity by storing water in vast reservoirs behind dams. Water from the reservoirs flows through turbines to generate electricity. Hydroelectric dams can generate large amounts of low-carbon electricity, but the number of sites suitable for new, large-scale dams is limited. Hydroelectric power can also be produced by run-of-river plants but most of the rivers that are suitable for this have already been developed. It has also been stated that while some dams generate hydroelectric power, others serve as reservoirs to store up water that can serve a particular geographical location.

List of All Dams/Reservoirs in Nigeria, their Locations and Uses

- Kainji Dam (Niger State) - Hydroelectric power generation
- Jebba Dam (Niger State) - Hydroelectric Power Station.
- Shiroro Dam (Niger State) - Generation of hydroelectricity.
- Asejire Reservoir (Oyo State) - Water supply.
- Bakolori Dam (Sokoto State) - Irrigation
- Challawa Gorge Dam (Kano State) - Hydropower generation.
- Dadin Kowa Dam (Gombe State) - Water supply for drinking but usage as irrigation and hydropower generation is planned for the future
- Goronyo Dam (Sokoto State) - Irrigation Supply
- Gusau Dam (Zamfara State) - Water supply for neighbouring communities and the city.
- Ikere Gorge Dam (Oyo State) – To be used for generating electricity, water supply and irrigation purposes.
- Jibiya Dam (Katsina State) – Irrigation and water supply
- Jabi Dam (Abuja) - Artificial reservoir for water supply and fishing purposes.
- Kafin Zaki Proposed Dam (Bauchi State) - Irrigation for agriculture with possible use for hydroelectric power generation
- Kiri Dam (Adamawa State) – Irrigation purpose being used by the sugar cane plantation called Savannah Sugar Company now owned by Dangote Industries.
- Mambilla Dam (Taraba State)
- Obudu Dam (Cross River State) - Irrigation, fishing, tourism and recreation functions.
- Oyan River Dam (Ogun State) - Water supply to Lagos and Abeokuta
- Tiga Dam (Kano State) - Hydropower generation.
- Zauro Polder Project (Kebbi State)
- Zobe Dam (Katsina State) - Irrigation and hydroelectric power generation purpose[2].

The Table 1 below gives the energy produced from the functional dams generating hydroelectric power in Nigeria[3].

Table 1 - Energy produced from dams in Nigeria

Power Station	Installed Capacity (MW)	Average Available Capacity (MW)	Average Operational Capacity (MW)
Kainji	720	444	173
Jebba	570	431	262
Shiroro	600	508	153
Total	**1,890**	**1,383**	**588**

Source: Nesistats

Fossil fuel power plants burn coal or oil to create heat which is in turn used to generate steam to drive turbines which generate electricity. In gas plants hot gases drive a turbine to generate electricity, whereas a combined cycle gas turbine (CCGT) plant also uses a steam generator to increase the amount of electricity produced. The Table 2 below gives the energy produced from Crude (natural gas thermal power plants).

Table 2 - Energy produced from Crude (natural gas thermal power plants)

Power Station	Installed Capacity (MW)	Average Available Capacity (MW)	Average Operational Capacity (MW)
Egbin	1320	941	539
Afam VI	685	587	455
Okpai	900	536	375
Transcorp Ughelli	480	463	374
Olorunsogo Gas	335	277	189
Ihovbor NIPP	434	374	182
Geregu NIPP	450	328	179
Olorunsogo NIPP	760	260	171
Omotosho Gas	335	280	163
Geregu Gas	414	159	131
Sapele NIPP	450	184	111
Ibom	190	91	76
Sapele	504	219	69
Alaoji NIPP	720	158	67
Odukpani NIPP	561	234	64
Afam IV-V	724	3	2
ASCO	294	270	0
Omoku	110	0	0
Trans Amadi	150	0	0
AES Gas	180	175	0
Rivers IPP (Independent Power Producer)	136	0	0

TOTAL	10,662	5,758	3,291

Source: Nesistats

Comparism between the Energy Produced From the Dams in Nigeria with Crude

Over the past century, the main energy sources used for generating electricity have been fossil fuels, hydroelectricity and, since the 1950s, nuclear energy. Despite the strong growth of renewables over the last few decades, fossil-based fuels remain dominant worldwide. The electricity sector in Nigeria is also mainly based on natural gas thermal power plants. Approximately 85% of the grid-connected power plants are fossil fuel (gas) fired, while the remaining 15% are hydroelectric power plants. Although it is important to note that currently only 3,500 MW to 5,000 MW is typically available for onward transmission to the final consumer. The total installed capacity of the 25 grid-connected generating plants in Nigeria is approximately 12,500 MW (Table 1&2 above), but many plants suffer from recurrent challenges such as maintenance and repair requirements, trips, faults, and leakages, that make them unavailable for evacuation to the national grid. Therefore, the average energy produced from the dams in Nigeria based on the average operational capacity of the power generating stations is 588MW while that of crude is 3,291MW[3].

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