Topic 1: Basic Energy Concepts

Introduction

Energy is the primary driver of economic development and is essential to sustaining the contemporary economy. The long-term accessibility of affordable, sustainable and friendly energy resources is fundamental for future economic growth. Industrialization helps the economy to grow and needs energy. Energy consumption and industrialization go hand in hand. The energy consumption will also expand if the economy grows. Economic growth relies on infrastructure development and infrastructure requires energy consumption. The two main infrastructural materials are steel (iron) and cement. These form the family of the major energy intensive industries (food processing, pulp and paper, chemicals, Iron and steel and oil refining sectors). In 2005 (similar trends also in the following years) for

Learning Outcomes of Topic 1

Upon completion of this study unit, you should be able to:

1. describe the history of energy and its importance
2. discuss the forms and sources of energy
3. explain the environmental impacts of energy use
4. apply electrical energy basics
5. determine the cost of electrical energy consumption

1.1 Overview of Energy

Energy is the ability of a body to do work. Whenever work is done, energy is used. Work usually causes a change. The change can be in position, temperature or a phase transition.

- Energy is the ability to produce, form, transform and animate.
- It is always conserved or converted into mass (Einstein’s mass-energy relation).
- It moves cars along the road and boats over the sea.
- It bakes a cake in the oven and keeps ice frozen in the freezer.
- It’s essential to modern life.
- We truly depend on energy.

Introductory discussion questions (Figure 1)

1. Where does the girl get her energy? How is she using energy?
   - *food that she eats*
   - *to move, see, hear, think, stay warm or cool*
2. Where does the television get its energy? What kind of energy does it make?
   - *Electricity*
   - *sound, light, heat*
3. Where does the car get its energy? What kind of energy does it make?
   - *battery and petrol*
   - *motion, sound, heat*
4. Where does the rain get its energy?
   - *the sun and gravity drive the water cycle*
5. Where does the corn get its energy?
   - *light from the sun*
6. Look around the lecture room/offices/laboratories/your house and point out things that are using energy. Decide where each item gets its energy and how it uses it.
   - *computer, clock, lights, plants, animals*

Figure 1: Energy

1.2 History of Energy

The historical record of energy use reveals how significant energy plays a role in economic growth. This can be looked in the following ways:

(a) Before Industrial Revolution
- For heat: sun and burned wood, straw (dried stalks of grain), and dried dung were used.
- For transportation: horses and the power of the wind in our sails were used.
- For work: animals were used to work where we were unable. Water and wind were used to drive simple machines for grinding (grains) and pumping water.

(b) Industrial Revolution (1750-1850)
- In the production and transportation: Machines replaced human and animal labor
- Steam engines for heat energy were started to be used.
- A single coal-driven steam engine does the work of dozens of horses.
- Agricultural, production, mining, transport and technological changes eventually influenced social and economical conditions.

(c) After Industrial Revolution
- Steam engines were soon powering locomotives, factories, and farms.
- Energy use grew quickly.
- The cost of energy production was declining steadily.
- Cars grew larger and heavier.

Nowadays
- More cars:
  - (i) Job growth in automobile-related industries
  - (ii) Major role in development of industrialized nations
- Cars altered people's lifestyles:
  - (i) Vacationers, greater distances
  - (ii) People could live further from work
    - ✓ Led to cities and suburbs.
    - ✓ Labor-savings, energy-consuming devices became essential
    - ✓ Energy dependent
- The invention of the automobile:
  - (i) Increased the demand for oil products
  - (ii) From 2% in 1900 to 40% in 2010

(d) Energy (Oil) crisis (1973): any great bottle neck (price rise) in the supply of energy resources to an economy. Briefly;
- The year 1973 finally brought an end to the era of secure and cheap oil.
- In October 1973, OPEC (Organization of Petroleum Exporting Countries) put an embargo on oil production and started the oil-pricing control strategy.
- Oil prices shot up causing a severe energy crisis the world over.
- This resulted in increased prices of various commercial energy sources,

- Further led to increased global inflation.
- Governments of all countries thought it for the first time, that there was a need for developing alternative sources of energy.
- Alternate energy sources were given serious consideration and huge funds were directed to their development.

The following were some of the causes of the oil crisis:

(i) Limited oil resources which are being exploited are controlled by a few countries.
(ii) Over reliance on fossil fuel and its products.
(iii) Prolonged drought which lowers production of hydel power hence calling for more demand on petroleum.
(iv) Artificial shortages caused by political disagreement e.g., the 1990 Gulf war.
(v) Rapid depletion of oil reserves due to overconsumption by machines that consume a lot of energy.
(vi) The steady increase in the world's population and its demands for fuel and products.
(vii) Low production due to poor (aging) infrastructure of power generating equipment.
(viii) Accidents like pipeline burst and natural calamities (volcanoes, floods, and earthquakes) can also cause interruptions to energy supplies.

Owing to the growing importance of energy awareness, efforts should be diverted to the following:

(i) Harnessing the large utilization of known and unknown energy reservoirs.
(ii) Development of energy conversion techniques to convert basic energy available from energy reservoirs to usable form of energy.
(iii) Keep the new energy system environmentally acceptable to human beings.
(iv) Development of cheap and reliable energy storage systems.
(v) Energy management.
(vi) Move from fossil fuels towards renewable resources.
(vii) Easier grid access by feeding excess energy into the grid.
(viii) Perform energy audit.
(ix) Adopting a common stand on climate change to reduce GHG emissions.

1.3 Why We Need Energy

We need energy:

(i) for powering our businesses, plants, factories
(ii) for lighting and heating homes and schools
(iii) for operating machinery, equipment and other appliances
(iv) to keep alive and maintain our bodies in motion

(v) to design, build and fuel vehicles, trucks, aircraft, vessels, ships
(vi) to run TVs, videos, music, games
(vii) power phones, computers
(viii) make our garments, dresses
(ix) to do everything else that we do.

1.4 Forms Of Energy

There are two types of energy, potential energy and kinetic energy.

(a) Potential energy is stored energy which is expected to be used. Potential energy is often more difficult to identify. Before we can use it, it must be transformed into kinetic energy.
(b) Kinetic energy is energy of motion. Motion of waves, electrons, atoms, molecules etc.

Examples:

- The food we eat contains chemical energy which is stored by the body. It is released only when we are doing work.
- At the top of the path, a roller coaster has potential energy which is converted into kinetic energy as it speeds down the path.

There are many forms of potential and kinetic energy. These include:

(i) Electrical energy: is the movement of electrons (tiny charged particles) through a conductor. The most advanced type of energy is electric power. Currently, about 30-40% of the world's power distribution is achieved by electrical supply systems. It can be transformed into other types of energy very conveniently and effectively.
(ii) Chemical energy: is the energy stored in the bonds of atoms and molecules. Wood stores chemical energy that is released when it burns.
(iii) Nuclear Energy: It is the energy stored in an atomic nucleus. It is the energy which holds together the nucleus. When the nucleus splits or fuses together, energy is released.
(iv) Stored mechanical energy: Energy stored in objects by the application of a force, e.g. compressed springs and stretched rubber bands. It is used in transportation, agriculture, handling, processing, and other industrial processes.
(v) Gravitational energy: energy of place or position e.g. the energy of water in a reservoir behind a dam is converted to kinetic energy when it is allowed to flow down.
(vi) Radiant energy is energy traveling as waves. It includes visible light, radio waves, x-rays, and gamma rays. Solar energy is an example of radiant energy.
(vii) Thermal energy is heat energy. It is used to cook, manufacture (raise temperature during industrial processes) and generate electricity, e.g. geothermal energy.

1.5 Sources Of Energy

A good energy source needs to provide a sufficient amount of useful energy and operate extensively. In addition among others, it should be easily accessible, affordable, easy to store and transport, environmentally friendly etc. Now, the most common sources of energy for producing different forms of power are discussed below.

(i) Fuel (fossil fuels oil, coal, and natural gas): The energy produced by burning fuel (such as wood) is in the form of heat. The chemical energy stored in the plants (wood) is converted and released in the form of heat (thermal energy) and light (radiant energy).

(ii) Atoms: The energy released from atoms by their nucleus is known as the nuclear energy. When the nucleus split or fuses, heat is generated which is used to boil water to produce electricity.

(iii) Hydropower: Water flows through the rivers when it rains. The power in moving water can be converted to hydro-power turning a turbine.

(iv) Solar Energy: it is the energy coming directly from the sun in the form of solar radiation. It has great promise mainly because it is available free of cost, has no effect on environment and needs no transportation since it is available everywhere.

(v) Radiant energy from the Sun make some parts of the Earth warmer than others. Air surrounding these warmer surfaces is heated, which causes it to rise. Cooler air then flows in to replace the heated air that has risen. This flow of air is called wind.

(vi) Radiant energy from the Sun also causes water to evaporate. The water vapor rises into the upper atmosphere forming tremendous energy in storms and winds.

(vii) Other renewable energy sources: The emphasis is on the sources which replenish themselves. They offer pollution-free environment and also help in maintaining the ecological balance, examples include, tidal energy, bio energy, solid waste, and geothermal energy.

(viii) Geothermal energy from cooling, chemical reactions and the radioactive decay inside the earth

(ix) The motion and gravitational potential of the sun, moon and earth.

1.6 Environmental Impacts Of Energy Use

Some atmospheric gasses trap heat in the same manner as a glass layer (in greenhouse). They are referred to as greenhouse gases. The resulting increase in temperature is known as the greenhouse effect. Water, air and the earth atmosphere absorb energy when the sunlight enters the earth's atmosphere. Some energy is reflected back in the atmosphere, but others are trapped by greenhouse gasses in the atmosphere. Increased greenhouse gas volume traps more heat into the atmosphere, leading to increased temperatures. The increase of the temperature across the planet is called global warming. This increased temperature can cause rainfall pattern, storm strength, melting polar ice and sea levels to change. This is called climate change.

Greenhouse gases occur both naturally and as the result of human activity (anthropogenic greenhouse effect). Some of the observed Climate Changes by the Intergovernmental Panel on Climate Change (IPCC, 2007) are presented below:

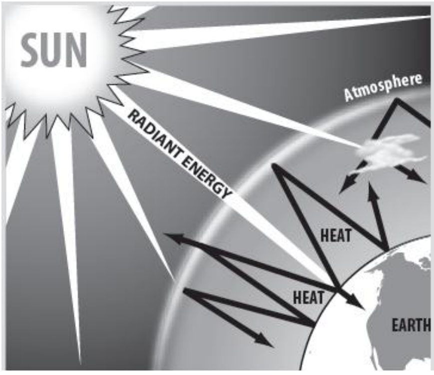

Figure 3: The Greenhouse Effect

(i) The global surface temperature rose by 0.74 °C between 1906 and 2005.
(ii) Eleven of the last 12 years have been the warmest since records were kept.
(iii) The increase in temperature during the last 50 years was twice as high as during the last 100 years.
(iv) The temperatures of the last 50 years have been higher than at any time in the last 1300 years.
(v) Glaciers are shrinking worldwide, as are the ice sheets on Greenland and Antarctica.
(vi) Since 1993 the sea level has risen an average of 3.1 mm per year. This is due to thermal expansion of the oceans, melting of mountain glaciers and melting of the arctic ice sheets.
(vii) The frequency of heavy precipitation has increased.
(viii) The frequency and intensity of droughts has increased since the 1970s.
(ix) The frequency of extreme temperatures has increased.
(x) Tropical cyclones have become much more intense since the 1970s.

The prime suspects of all the aforementioned changes in the climatic conditions are the greenhouse gases with carbon dioxide on the lead. The major greenhouse gases are:

(a) Carbon dioxide (CO2) – released when we burn oil, coal, and natural gas. It also comes from biomass and volcanoes.
(b) Methane (CH4) – comes from decomposition of wastes in landfills, coal mines, oil and natural gas operations, and agriculture.
(c) Nitrous oxide (N2O) – comes from the use of nitrogen fertilizers and combustion of fossil fuels.
(d) Other greenhouse gases are hydro fluorocarbons (HFCs), ozone and sulphur hexafluoride (SF6).

There is currently extensive evidence that increased CO2 levels are one of the primary causes of global warming. The major cause of the rise in CO2 levels is the use of fossil energy. When we use (burn) fossil fuels, this is considered as a chemical oxidation which releases heat. Thus we use the heat impact which results in combining petroleum, natural gas and coal with oxygen. The waste product we get in return is CO_2 in enormous quantities. This implies that every way we produce energy somehow affects our environment. Therefore, you want to reflect again on the impacts of coal and uranium mining; petroleum drilling; natural gas fracturing of underground rock; tree cutting; waste disposal from coal burning and nuclear power plant. It is essential that we therefore make wise use of our energy resources and safeguard the environment.

1.7 Climate Protection

The Rio (1992) world summit on climate declared that protecting the environment was absolutely essential. The first targets for reducing greenhouse gas emissions were agreed in 1997 (Kyoto, Japan) in what was known as Kyoto Protocol.

(i) The Protocol obligates all the treaty parties to reduce their emissions of greenhouse gases by an average of 5.2% by 2012 at the latest (the USA is the only country that did not ratified it). However, different restrictions apply to different individual treaty parties.

(ii) The protocol considers the following greenhouse gases and converted into carbon dioxide equivalents: methane (CH_4), nitrous oxide (laughing gas, N_2O), partially halogenated chlorofluorocarbons (CFC), perfluorocarbons (PFC) and sulphur hexafluoride (SF_6).

(iii) The Kyoto Protocol which came into effect in 2005 further plans no restrictions for developing and emerging countries.

Although these targets still do not go far enough, they have succeeded in putting international pressure on countries to implement the measures necessary to protect the climate. If these plans are taken seriously, a reduction in greenhouse gases of 50 to 80% by the year 2050 should be easily achievable.

Active climate protection does not demand any major sacrifices. If everyone tried to implement the following measures, it would be enough to save the climate:

(i) Manufacturers to produce coolant-free HFC equipment and appliances, as they account for more than 10% of the greenhouse effect.

(ii) Be consistent in recycling

(iii) Be consistent in saving energy in all areas

(iv) Disconnect your equipments when leaving the house. The result is an ongoing energy flow without any application.

(v) Stop cutting down trees. This may trigger change in climate, desertification, soil erosion, fewer plant habitats, floods, enhanced atmospheric greenhouse gasses.

(vi) Encourage renewable energy systems and installations. For fossil fuels let it go. We should learn to forego fossil fuels in order to sustain the planet for future generations.

(vii) Education of the public on the misuse of resources that may lead to pollution.

(viii) Saying no to plastics is a way out of climate change. It is detrimental to both the people and biodiversity. The ban on plastics reduces pollution concentrations.

(ix) Avoid buying products made of tropical woods that do not come from sustainable sources. The forest stamp can help in a purchase decision.

(x) The most resource-efficient delivery of public services to enable sustainable communities through excellent land use and urban planning, government transport and adequate support.

(xi) Protecting and restoring important ecosystems is essential. Governments must safeguard the most important habitats to combat climate change: rivers, wetlands, oceans, forests and mangroves absorb big carbon amounts thereby slowing warming. Mangroves also serve to prevent tropical storms and wetlands absorb excess water from floods, which is compounded by extreme weather events.

Other important Climate-related international conferences:

1. 1998 (Delhi, India): 1st Assembly Meeting of the Global Environment Facility.
2. 2001 (Marrakech, Morocco): 7th Session of the UN Framework Convention on Climate Change.
3. 2002 (Delhi, India): 8th Session of the UN Framework Convention on Climate Change
4. 2003 (Moscow, Russia): World Climate Change Conference.
5. 2007 (Bali, Indonesia): 13th Session of the UN Framework Convention on Climate Change.
6. 2008 (Monaco, France): 10th Special Session of the UN Environmental Program.
7. 2008 (Beijing, China/PRC): Forum on Climate Change and Science and Technology Innovation
8. 2008 (Hokkaido, Japan): G-8 Summit
9. 2008 (Poznan, Poland): 14th Session of the UN Framework Convention on Climate Change
10. 2009 (Aquila, Italy): G-8 Summit
11. 2009 (New York, USA): UN Summit on Climate Change
12. 2009 (Copenhagen, Denmark): 15th Session of the UN Framework Convention on Climate Change
13. 2010 (Cochabamba, Bolivia): Peoples' World Conference on Climate Change and the Rights of Mother Earth
14. 2010 (Cancun, Mexico): 16th Session of the UN Framework Convention on Climate Change and 6th Session of the Conference of the Parties serving as the Meeting of the Parties to the Kyoto Protocol
15. 2011 (Durban, South Africa): 17th Session of the UN Framework Convention on Climate Change
16. 2012 (Rio de Janeiro, Brazil): UN Conference on Sustainable Development (Rio + 20)

17. 2012 (Doha, Qatar): 18th Session of the UN Framework Convention on Climate Change and 8th Session of the Conference of the Parties serving as the Meeting of the Parties to the Kyoto Protocol
18. 2015 (Paris, France): 21st Session of the UN Framework Convention on Climate Change
19. 2016 (Marrakesh, Morocco): 22nd Session of the UN Framework Convention on Climate Change
20. 2017 (Bonn, Germany): 23rd Session of the UN Framework Convention on Climate Change

1.8 Electrical Energy Basics

Here, we shall explore the basic concepts, terminologies and electrical measuring instruments. The main terms associated with electricity are as follows: Current; Voltage; Power and Energy.

Voltage (V)

- Voltage is a measure of the pressure applied to electrons to make them move. It is a measure of the strength of the current in a circuit and is measured in volts (V).
- If voltage is more, the pressure on electrons would also be more forcing into more current.
- Small voltage levels can run small electrical appliances and large voltage levels can run large electrical appliances. For example, a 1.5 V battery is sufficient for lighting small bulbs in flash lights and a 12 V car battery can run large lamps in the car.

Electric current (I)

- Electric current is defined as electrons flow rate between two points having a difference in voltage. Current is measured in amperes or amps (A).
- The flow of electrons through a wire is similar to the flow of water through a pipe. The water current is the number of molecules flowing past a fixed point. Similarly, electrical current is the amount of charge (electrons) flowing past a fixed point.
- Current flow is possible only when voltage is available.
- Electric current is divided into two types: direct current (DC) e. g. current produced by batteries and alternating current (AC) e.g. household electricity produced by generators, electricity supplied by utilities.

Resistance (R)

- Resistance is a property that slows the flow of electrons. Different materials have different resistances. Resistance is measured in units called ohms (Ω). There are devices called resistors, with set resistances, that can be placed in circuits to reduce or control the current flow. Any device placed in a circuit to do work is called a load (light bulb, television). Every load has resistance.
- One of the limitations of resistance of a wire is the voltage drop across it when current flows. The voltage drop means drop of electrical pressure to drive the

current. The amount of voltage drop depends on resistance and current flowing through the wire. It is represented by the following equation:

$$Voltage = Current \times Resistance$$

$$or \quad V = I \times R$$

Electric Power (P)

- Power is a measure of the rate of doing work, or the rate at which energy is converted. Electric power is the rate at which electricity is produced or consumed.
- Using the water analogy, electric power is the combination of the water pressure and the rate of flow that results in the ability to do work. A large pipe carries more water (current) than a small pipe. Water at a height of 10 meters has much greater force (voltage) than at a height of one meter.
- Electric power is the amount of electricity required to start or operate a load for one second. It is measured in watts (W). The formula is:

$$power = Voltage \times Current$$

$$P = V \times I$$

$$or \quad (W) = (V) \times (A)$$

Electrical Energy

- Electrical energy introduces the concept of time to electric power. When we talk about using power over time, we are talking about using energy. The electrical energy that an appliance or device consumes can be determined only if you know how long (time) it consumes electric power at a specific rate (power).
- To find the amount of energy consumed, you multiply the rate of energy consumption (measured in watts) by the amount of time (measured in hours) that it is being consumed. Electrical energy is measured in watt-hours (Wh).

$$Energy = Power \times Time$$

$$E = P \times t$$

$$or \quad (Wh) = (W) \times (h)$$

Measurements of Electrical Quantities

- There are many types of meters available which can measure voltage, current, power and energy. A multimeter is a measuring instrument that combines several measurement functions in one unit. A typical multimeter may include features, such as the ability to measure voltage, current and resistance.
- Multimeters can also be used for fault detection in small circuits or to find out the broken wires in a circuit.

1.9 Energy Units And Dimensions

We use the International system of units (SI units), which is based on the dimensions and basic units in Table below.

Table 1.1: Energy units

NO.	QUANTITY	BASIC UNIT	UNIT SYMBOL
1.	Length	metre	m
2.	Mass	kilogram	kg
3.	Time	second	s
4.	Electric Current	ampere	A
5.	Temperature	Kelvin	K

The unit of energy in this unit system is joule (J), and the unit of power is watt (W). One joule is the ability to overcome one newton along 1 meter. Other non SI units are discussed below:

1. Electron volt, 1 eV = Energy gained by an electron due to 1 $volt$ potential difference
2. Erg: The erg is the unit of energy in the cgs system. It is the force required to accelerate a mass of one gram at a rate of one centimetre per second square
$$1\ erg = 10^{-7}\ J$$
   - ☞ 1 erg is approximately the amount of energy required for a mosquito to take off.
3. Calorie, cal: the calorie is the amount of heat required to raise the temperature of 1 g of water by 1$°C$, from 14.5 $°C$ to 15.5 $°C$. Common unit used by medical professionals.
$$1\ cal = 4.187\ J$$
4. British Thermal Unit, BTU: is a measure of the quantity of heat, defined as approximately equal to 1,055 joules,
$$1\ BTU = 1.055 \times 10^{3}\ J$$
5. Horsepower hour (metric), hp.hr: This is an outdated unit of energy, not used in the SI system of units. It represents an amount of work a horse is capable of delivering in 1 hr
$$1\ Hp\ hr = 2.646 \times 10^{6}\ J$$
6. Kilowatt hour, kWh: is a unit of energy equivalent to 1 kW of power expended for 1 h.
   - ☞ The consumption of electrical energy by homes and small businesses is usually measured in kilowatt-hours.
   - ☞ Larger businesses and institutions use the megawatt-hour (MWh)
   - ☞ Large power plants, energy consumption of nations is gigawatt hours (GWh), where $1\ GWh = 1{,}000\ MWh = 10^{6}\ kWh$.
$$1kWh = 3.60 \times 10^{6}\ J$$
7. Barrel Oil Equivalent, BOE: This is the approximate energy released by burning one barrel of crude oil.
$$1 \text{ barrel of oil} = 42 \text{ U.S. gallons (gal)} = 158.9873\ litres$$
$$1\ BOE = 6.119 \times 10^{9}\ J$$
8. Ton Wood Equivalent: The ton wood equivalent is the energy released by burning 1000 kg of wood.
$$1\ TWE = 9.83 \times 10^{9}\ J$$
9. Ton Coal Equivalent, TCE: Unit representing energy generated by burning 1000 kg of coal

$$1\ TCE = 29.31 \times 10^9\ J$$

10. Ton Oil Equivalent, TOE: Unit representing energy generated by burning $1000\ kg$ of oil

$$1\ TOE = 41.87 \times 10^9\ J$$

1.10 Prefixes

The powers of ten are often abbreviated by writing prefixes before the unit. Common prefixes are given in Table below.

- Prefixes are used to simplify the description of physical quantities that are either very big or very small;
- e.g., the mass of an electron is $9.1 \times 10^{-31}\ kg$ (very small) while that of the sun is $2.0 \times 10^{30}\ kg$ (very large). The table below defines the accepted prefixes.

Table 2.2: Prefixes

PREFIX	SYMBOL	MULTIPLIER
exa	E	10^{18}
peta	P	10^{15}
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	K	10^{3}
hecto	h	10^{2}
deca	da	10^{1}

1.11 ENERGY CONVERSION

Energy can neither be created nor destroyed; this is called the law of energy conservation. Energy converts among various forms without any loss or gain. During the application of energy, it changes from one form to other, for example:

- Combustion (chemical energy of plants is converted to heat energy),
- Use of external combustion engine and Internal combustion engine (heat energy is converted to mechanical energy)
- Use of electromagnetic devices (mechanical energy is converted to electrical energy)
- Use of fan (electrical is converted to mechanical)
- Nuclear reactors convert nuclear energy (nuclear fission)to thermal and then electric energy
- Nuclear fusion reactors convert fusion energy to electric energy
- Batteries and fuel cells convert chemical energy into electric energy

- Audio and visual equipment converts electric energy into electromagnetic radiation, and sound energies
- Electrolyses convert electric energy into chemical energy

The following is an example of the transformation of different types of energy into heat and power: Oil burns to generate heat, Heat boils water, Water turns to steam, Steam pressure turns a turbine, Turbine turns an electric generator, Generator produces electricity, Electricity powers light bulbs, and Light bulbs give off light and heat

1.12 Commercial Unit Of Electricity

Electrical energy is calculated in terms of unit of electricity.

$$1\ kWh = 1\ unit\ of\ electricity$$

One kilowatt-hour is the amount of electrical energy used when a $1\ kW$ appliance is on for one hour.

$$\begin{aligned} 1\ kWh &= 1\ kW \times 1\ h \\ &= 1000\ W \times 3600\ s \\ &= 3600000\ J \\ or \quad 1\ kWh &= 3.6 \times 10^{-6}\ J \end{aligned}$$

The electrical energy used at homes and industries are expressed in kWh. The cost of electricity is calculated using the following formula:

$$\begin{pmatrix} Cost\ of \\ electricity \end{pmatrix} = \begin{pmatrix} Unit\ of \\ electricity \end{pmatrix} \times \begin{pmatrix} Rate\ per\ unit\ of \\ electricity \end{pmatrix}$$

1.13 Cost Of Electrical Energy Consumption

The electrical cables entering a home pass into a meter which records the total electrical energy used by the consumers.

UMEME charges electricity used according to the number of kilowatts-hours used

- The amount of electrical energy used in a household is measured in kilowatt-hour (kWh).

$$\begin{pmatrix} Electrical\ energy \\ in\ kWh \end{pmatrix} = \begin{pmatrix} Power \\ in\ kW \end{pmatrix} \times \begin{pmatrix} Time \\ in\ h \end{pmatrix}$$

Summary of Topic 1

In this topic 1, you have learnt the following:

1. History of Energy
2. Why We Need Energy
3. Forms of Energy
4. Sources of Energy
5. Environmental Impacts of Energy Use
6. Climate Protection
7. Electrical Energy Basics
8. Energy Units and Dimensions
9. Prefixes
10. Energy Conversion
11. Unit of Electricity and Cost of Electrical Energy Consumption

Self-Review Questions

Now that you have completed this study unit, you can assess how well you have achieved its Learning Outcomes by answering these questions. Write your answers in your Study Diary and discuss them with your Tutor at the next Study Support Meeting or Online interactive sessions. You can also check your answers at the Self-Review Answers section which is located at the end of this Module.

1. Define the term energy. Explain its significance in context of techno-socio-economic development.
2. What is the main source of energy for earth?
3. Define radiant energy.
4. State the law of conservation of energy.
5. What is climate change?
6. Why do sea levels change?
7. Briefly discuss how does agriculture affect climate change?
8. What are carbon emissions?
9. What is the greenhouse effect and why does an increased greenhouse effect lead to climate change?
10. Discuss any three key recommendations of the Kyoto Protocol to the treaty parties
11. Can we stop climate change? Discuss what you can do as an individual to actualize this.
12. Define the term tons oil equivalent
13. Define the following terms:
    (a) Current
    (b) Voltage

(c) Power

14. Calculate the current flowing through a 1 kW heater when it is connected to the mains supply (220 V). Find also the resistance of the element of the heater
15. A small heater with a resistance of 100 Ω is connected to a 220 V supply. Calculate the current and the heat energy it gives off per minute.
16. Calculate the maximum safe current for (a) a 2 $M\Omega$ resistor of power 5 W and (b) a 1 $k\Omega$ resistor of power 2 W.
17. In a model of a power line, a 12 V A.C. supply of negligible resistance is connected by wires of total resistance 4 Ω to a lamp of resistance 6 Ω. Calculate:
    (a) the current flowing in the wires,
    (b) the power loss in the wires,
    (c) the voltage drop along the power line,
    (d) the power converted in the lamp.
18. Based on the latest UMEME power rates and billing structure released on the 10th July 2019; the following are the power tariff structure:
    (a) The first 15 units cost UGX. 250 per unit
    (b) The proceeding units are charged UGX. 755.1 per unit
    (c) Monthly service fee of UGX. 3,360
    (d) Charges on VAT is 18%

Name	Quantity	Power rating	Time/day
1. Bulb (Philips)	6	100 W	7.5 hr
2. Fans (Sitting Rooms)	2	50 W	9.5 hr
3. LG TV Flat Screen	2	100 W	5 hr
4. Electric Iron	2	1000 W	25 hr
5. Electric Stove	1	750 W	1.2 hr

The table above gives the electrical appliances used, their power, and the average time for which they are used each day by Mr. Smith at his home near Ggaba landing site. Estimate the monthly electricity bill of Mr. Smith.

References and Additional Reading Materials

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