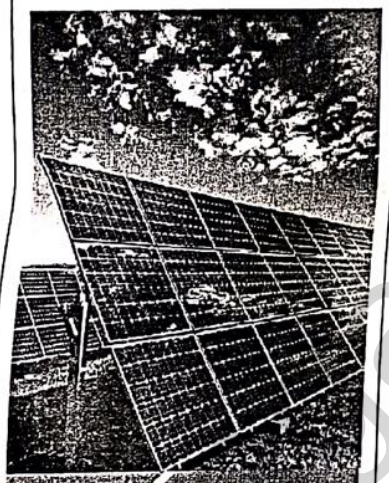
O Level Physics Syllabus Content for CAIE 2019-22 Exams

CHAPTER 8:
ENERGY SOURCES AND TRANSFER OF ENERGY



Syllabus Content

8.1 Energy forms **8.2** Major sources of energy
8.3 Work **8.4** Efficiency **8.5** Power

Learning outcomes

Candidates should be able to:

a) List the different forms of energy with examples in which each form occurs.

b) State the principle of the conservation of energy and apply this principle to the conversion of energy from one form to another.

c) State that kinetic energy is given by $E_k = \frac{1}{2}mv^2$ and that gravitational potential energy is given by $E_P = mgh$, and use these equations in calculations.

d) List renewable and non-renewable energy sources.

e) Describe the processes by which energy is converted from one form to another, including reference to

1. Chemical/fuel energy (a re-grouping of atoms),
2. Hydroelectric generation (emphasising the mechanical energies involved),
3. Solar energy (nuclei of atoms in the Sun),
4. Nuclear energy,
5. Geothermal energy,
6. Wind energy.

f) Explain nuclear fusion and fission in terms of energy-releasing processes.

g) Describe the process of electricity generation and draw a block diagram of the process from fuel input to electricity output.

h) Discuss the environmental issues associated with power generation.

i) Define work done and use the formula work = force × distance moved in the line of action of the force.

j) Recall and use the formula efficiency = energy converted to the required form/total energy input for an energy conversion.

k) Discuss the efficiency of energy conversions in common use, particularly those giving electrical output.

l) Discuss the usefulness of energy output from a number of energy conversions.

m) Define power and recall and use the formula power = work done/time taken.

ABDUL HAKEEM (0300-4810136)O / AS & A Level Physics

ENERGY SOURCES AND TRANSFER OF ENERGY

Energy is the capacity of a body to perform some useful work. To transfer energy from one form to other work must be done.

Energy has several different forms:

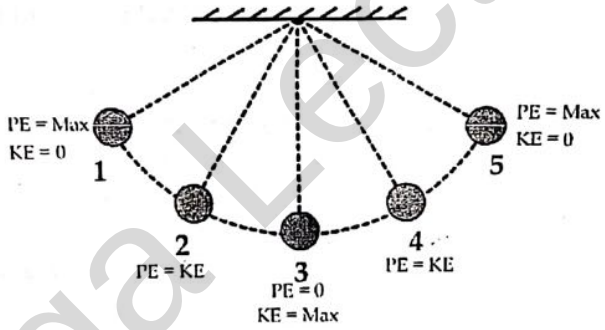
Work: is the mechanical energy. Work is done when the force moves a body through a distance. Work = force × distance moved in the direction of force.

$$W = F \times d_{Parallel}$$ measure in Joules. (J)

"One Joule is the work done by one Newton force to move a body through a distance of one meter. *"Work is the product of force and distance covered in the direction of force"*

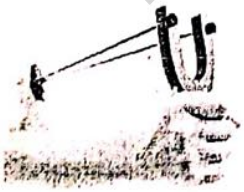
Kinetic Energy: is the energy of a body due to its speed / motion. The kinetic energy equals half the mass times the square of velocity, thus

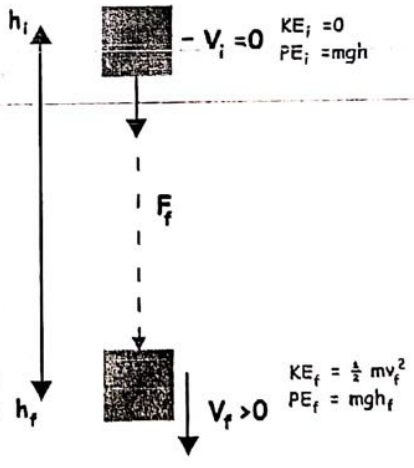
$$K.E = \frac{1}{2} mv^2$$ Measured in Joules



Potential Energy:

Potential energy is energy stored inside the body in some form and is waiting to be used later, it can have several forms.





a) **Gravitational Potential Energy** stored in an object due to its height above the ground, it is given by: P.E.= m g h (Measured in Joules)

ABDUL HAKEEM 03004810136

(When an object is falling, its P.E. is gradually decreasing and changing to K.E., when it is completely stopped the energy is converted to internal energy (heat) and sound.

b) **Strain Potential Energy** stored in a stretched elastic band as in the case of a catapult, or wound-up spring (it can be converted to kinetic energy).
c) **Chemical Potential Energy** stored in chemical materials (in batteries, muscles, fuel,) and can be released due to regrouping of atoms during the chemical reactions.

Internal Energy: is the energy due to molecular motions inside the body (translations, vibrations and rotations). It increases by the rise in temperature.

Heat Energy: flows from one body to another due to temperature difference between them. Heat flows from the body at higher temperature to the body at a lower temperature. There are other forms of energy like nuclear, electromagnetic (light), sound, etc. Energy can be transformed from one form to another.

Conservation of energy and mass:

The sum of mass plus energy of a system is fixed. The mass and energy of a closed system is always constant, it cannot increase or decrease.

Conversion of mass and energy:

In some processes, a small mass "m" "disappears" and is converted to equivalent amount of energy, where. Energy produced = m c^2 (c is speed of light). This relation is called ("Einstein's Relation") or mass / energy relation.

Law of Conservation of Energy

Energy neither be created, nor be destroyed. It is only transferred from one form to other.

Sources of Energy

Renewable energy sources are those where energy can be recycled (reused) and resources (reservoirs) are unlimited e.g. water, wind and solar energy etc. Non renewable energy sources are those where energy cannot be recycled and reservoirs are limited e.g. oil, gas and fossil fuels etc.

1. **Nuclear Fusion** occurs in the sun where light nuclei of hydrogen are fused or combined together to produce a heavier nucleus (helium) and produce great amounts of energy. (This is the hydrogen bomb reaction).
2. **Nuclear Fission** occurs in nuclear reactors where heavy nuclei of Uranium are broken up into lighter nuclei (fragments) and large amounts of energy are produced. This energy changes water to steam which derives power stations to generate electricity.

Nuclear reactors are sited near the sea for optimum free cooling. Sea temperature rises causing a shift in ecology. There are also the problems of disposal of radioactive waste, and the danger of leakage and environmental pollution.

3. **Muscular Energy** comes from the chemical energy stored in food. It is released by chemical reactions in our bodies.
4. **Wind Power:** energy of moving air is used in sailing ships and windmills wind turbines can generate electricity. It requires large clusters of huge windmills using large areas of land. The wind is variable from time to time and its initial cost is high, yet it is clean and renewable source of energy.
5. **Fuel Energy:** Solar energy has been stored since millions of years in fossil fuels (coal, oil, natural gas). This energy is released as heat when fuel is burnt. Fuels are expensive and are not renewable. Waste gases, like carbon and sulphur oxides, give rise to atmospheric pollution. CO_2 in the atmosphere may cause the "greenhouse effect" and raises the temperature of the earth.
6. **Solar Energy:** can be used directly by green plants (photosynthesis) or by photo cells and solar panels. Solar energy is cheap, clean and renewable, but it needs very large areas of land to collect enough solar energy.
7. ***Hydroelectric Power Stations:*** The energy of falling water derives a turbine which can derive a generator to produce electricity. It is clean inexpensive and renewable source. Unless using a natural water fall, hydroelectric power required flooding large areas of land to make necessary reservoirs.
8. **Geothermal Energy:** Heat can be extracted from vast store of heat inside the earth, or from hot rocks due to radioactivity in the ground. Two pipes several kilometers long are dug into the ground; water is pumped down in one pipe and steam comes out of the other pipe. Steam can derive turbines and generators to produce electricity or can heat buildings.

   This source is not available in any place, it needs certain suitable sites, it is technically difficult and can be expensive.

9. **Tidal Energy:** When high tide approaches, sea water rushes to fill a lake where it is trapped by a dam. At low tide, water flows out deriving turbines and generators to produce electricity.

This method is not available for all countries, and its initial cost is high (it is similar to hydroelectric stations). A source of energy is judged to be a "good" source or not according to these criteria:

i. Is it a clean source or does it cause pollution?
ii. Is it a cheap source or is it expensive?
iii. Is it a renewable source or not?

ABDUL HAKEEM 03004810136

Wind Power Station

Kinetic Energy of the Wind
↓
Rotational Kinetic Energy of Turbine
↓
Electric Energy from Generator
↓
Electric Energy from the Transformer

Advantages	Disadvantages
Reduces consumption of fossil fuels for electricity production	Wind generators are only feasible in certain areas
Reduces production of greenhouse gases	Each wind turbine kills about one bird per year
Reduces production of pollution	Wind generators make a humming sound that can be heard nearby
Can provide extra income for farmers	Wind generators are tall and can block the views of nearby scenery
Wind is a renewable energy resource	

Nuclear Power Station

Nuclear energy from the Uranium
↓
Heat energy from the Nuclear Reactor
↓
Steam energy from the Boiler
↓
Rotational kinetic energy from turbine
↓
Electric energy form generator
↓
Electric energy from transformer

Advantages:

- Nuclear power plant is more economical compared with thermal plants where coal field is far away.
- Manpower requirement is less. Therefore cost of operation reduced.
- Nuclear plant occupies less space than thermal power plant, which reduces the cost of civil construction

Disadvantages

- Handling should be very careful. There is a danger of nuclear radiation.
- Disposing the radioactive waste is very difficult
- it has to be operated at full load throughout for good efficiency.

Power

Power is the work done per unit time i.e. it is the rate of doing work.

$$\text{Power} = \frac{\text{workdone}}{\text{timetaken}} = \frac{\text{energychange}}{\text{timetaken}}$$

Power is measured in J/s or Watt (W). One Watt equals one joule per second.

1 kilowatt (Kw) = 1000 W

1 megawatt (MW) = 1,000,000W

Or, Power equals the force time's average velocity.

Example: A fork lift truck can raise a load of 315 kg to a height of 2 m in 30 seconds. What is the developed?

Solution: Work done = (mg) x h

= 315 x 10 x 2

= 6300 J

$$\text{Power} = \frac{\text{work done}}{\text{time take}} = \frac{6300}{30} = 210 \text{ W}$$

ABDUL HAKEEM 03004810136

Energy Transformation

Hydroelectric Power Station

Gravitational potential energy of water in dam
↓
Rotational kinetic energy of turbine
↓
Electric potential energy from generator
↓
Electric energy from transformer

Advantages	Disadvantages
• Renewable • Water can be used for recreation or irrigation. • Once the dam is built, it is virtually free and lasts a very long time • Produces no waste/pollution • Very reliable method to create electricity	• Dam is expensive to built. • Building dams leads to flooding upstream. • Dams can affect wildlife living in the rivers (ex salmon spawning).

Thermal Power Station

Chemical energy of the fuel
↓
Thermal (heat) energy
↓
Internal energy of steam of water
↓
Rotational kinetic energy of turbine
↓
Electric potential energy from generator
↓
Electric energy from transformer

ADVANTAGES:

- The fuel used is quite cheap.
- Less initial cost as compare to other generating stations.
- It can be installed at any place irrespective of the existence of coal. The coal can be transported to the site of plant by rail or roads.

DISADVANTAGES:

- It pollutes the atmosphere due to producing large amount of smoke and fumes.
- Higher maintenance cost and operational cost.
- Huge requirement of water.

Solar Power Station

Solar Energy from Sun
↓
Electric Energy (D.C) in Solar Panels
↓
Electric Energy (A.C) in Inverter
↓
Electric Energy from the Transformer

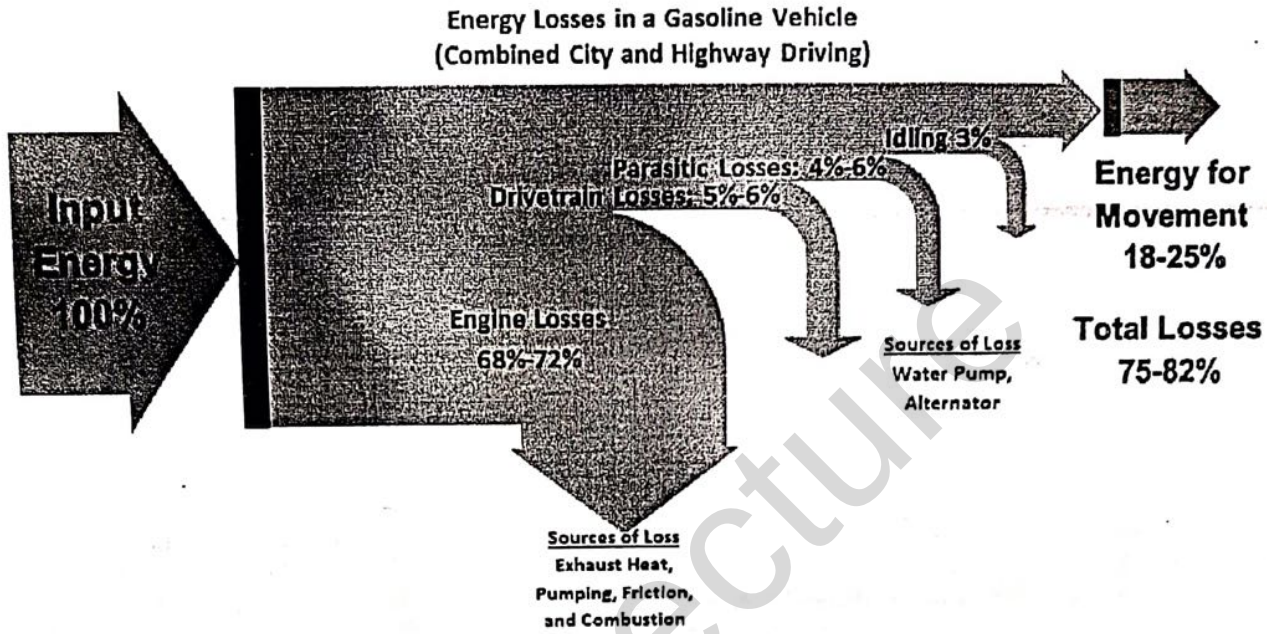
Advantages	Disadvantages
SOLAR PANELS	
1. Can be used almost anywhere 2. Extremely low maintenance 3. Very long system life spans 4. Can be operated unmonitored for extended periods of time 5. Predictable power output in most locations 6. Simple installation 7. Silent, unobtrusive operation	1. High initial cost for solar panels 2. Power output can be variable in some areas, necessitates the use of a large battery bank and / or alternate power source 3. Requires good solar exposure (not practical in shaded areas, etc.)

ABDUL HAKEEM 03004810136

Efficiency:

In practice, the energy (or power) output of a machine is less than the energy (or power) input due to frictional losses which usually appear as heat and sound.

$$\text{Efficiency} = \frac{\text{Energy output}}{\text{Energy input}} \times 100\%$$



Input energy = lost energy + useful output energy