

UNIT 3

Electrical Energy



Start up

Answer the following questions:

1. Is electricity itself a form of potential or kinetic energy – or both? Explain.
2. What is an electric field?
3. What is static electricity?
4. Name some methods of generating electricity



Reading

What is Electrical Energy?

Energy is the ability to do **work**, where work is done when a force moves an object. We need and we use energy every day, and energy is available in all different forms. **Electrical energy** is energy that is stored in charged particles within an electric field. **Electric fields** are simply areas surrounding a charged particle. In other words, charged particles create electric fields that exert force on other charged particles within the field. The electric field applies the force to the charged particle, causing it to move - in other words, do work.

Methods of generating electricity

There are seven fundamental methods of directly transforming other forms of energy into electrical energy:

1. Static electricity, from the physical separation and transport of charge (examples: triboelectric* effect and lightning)
2. Electromagnetic induction, where an electrical generator, dynamo or alternator transforms kinetic energy (energy of motion) into electricity. This is the most used form for generating electricity and is based on Faraday's law. It can be experimented by simply rotating a magnet within closed loops of a conducting material (e.g. copper wire)
3. Electrochemistry, the direct transformation of chemical energy into electricity, as in a battery, fuel cell or nerve impulse
4. Photovoltaic effect, the transformation of light into electrical energy, as in solar cells
5. Thermoelectric effect, the direct conversion of temperature differences to electricity, as in thermocouples, thermopiles, and thermionic converters.
6. Piezoelectric effect, from the mechanical strain of electrically anisotropic molecules or crystals. Researchers at the US Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab) have developed a piezoelectric generator sufficient to operate a liquid crystal display using thin films of M13 bacteriophage.
7. Nuclear transformation, the creation and acceleration of charged particles (examples: betavoltaics or alpha particle emission)

Static electricity was the first form discovered and investigated, and the electrostatic generator is still used even in modern devices such as the Van de Graff generator** and MHD generators***. Charge carriers are separated and physically transported to a position of increased electric potential. Almost all commercial electrical generation is done using electromagnetic induction, in which mechanical energy forces an electrical generator to rotate. There are many different methods of developing the mechanical energy, including heat engines, hydro, wind and tidal power. The direct conversion of **nuclear potential energy** to electricity by beta decay is used only on a small scale. In a full-size nuclear power plant, the heat of a nuclear reaction is used to run a heat engine. This drives a generator, which converts mechanical energy into electricity by magnetic induction. Most electric generation is driven by heat engines. The combustion of **fossil fuels** supplies most of the heat to these engines, with a significant fraction from **nuclear fission** and some from **renewable sources**. The modern **steam turbine** (invented by Sir Charles Parsons in 1884) currently generates about 80% of the electric power in the world using a variety of heat sources.

New Technologies

Renewable electricity has changed fast in the last five years. Perovskite-silicon tandem panels now capture more colours of sunlight and reach laboratory efficiencies of 33 %. Far out at sea, floating wind turbines stand on semi-submersible platforms and harvest stronger, steadier winds. In the nuclear field, Small Modular Reactors (SMRs) leave the factory as complete 300 MW units and use passive cooling, so they can follow solar output hour-by-hour. Surplus midday power no longer goes to waste: it feeds large electrolyzers that split water into green hydrogen, a clean fuel for buses, trucks and industry.

Modern Ways to Store Electricity

The world still trusts the lithium-ion battery, but new chemistries are coming fast. A solid-state lithium cell swaps the flammable liquid for a thin ceramic and stores 40% more energy per kilogram. A sodium-ion battery replaces costly lithium with common table salt—ideal for large solar parks on the Greek mainland. Where life demands speed, super-capacitors fill and empty in seconds and survive a million cycles; city buses top up at every stop. In the mountains, pumped-hydro plants lift water uphill at noon and let it rush back through turbines at night with about 80% round-trip efficiency. Even parked electric cars can help: with Vehicle-to-Grid (V2G) software they lend a few kilowatt-hours to the grid at peak time and earn the owner a fee.



Comprehension and vocabulary exercises

A. Match the words of the two columns, according to the text:

- | | | |
|------------------------------|--------------------------|---|
| 1. Piezoelectricity | ☐ | a. kinetic energy into electricity |
| 2. Static electricity | ☐ | b. solar cells |
| 3. Nuclear potential energy | ☐ | c. thermocouples |
| 4. Photovoltaic effect | ☐ | d. pressure applied to certain crystals |
| 5. Electromagnetic induction | ☐ | e. beta decay |
| 6. Thermoelectricity | ☐ | f. electrostatic generator |

B. Complete the sentences with the appropriate word(s):**Thermoelectric effects, electrochemistry, electrical energy, static electricity, photo electricity, piezoelectricity**

1. Doors that open and close automatically are an example of.....
2. Lightning is an example of.....
3. Rubbing a piece of amber with wool causes.....
4. If you've got a quartz watch..... is what helps it keep regular time
5.can be used to make solid-state refrigeration devices, or to sense temperature differences, or to convert thermal energy directly into electricity
6. A battery is an example of

C. Fill in the blanks with the appropriate word:**Electrical, voice recognition, gramophone, piezoelectricity, crystals**

If you've been writing a letter or an essay on your computer with the help of software, the microphone you spoke into probably usedto turn the sound energy in your voice intosignals your computer could interpret. If you're a bit of an audiophile and like listening to music on vinyl, your would have been using piezoelectricity to "read" the sounds from your LP records. Piezoelectricity (literally, "pressing electricity") is much simpler than it sounds: it just means usingto convert mechanical energy into electricity or vice-versa.

D. Put the phrases in the right order to create a meaningful paragraph:

1. In a full-size nuclear power plant, ☐
2. By magnetic induction ☐
3. A heat engine drives a generator ☐
4. The generator converts mechanical energy into electricity ☐

E. Match the nouns to their definitions

- | | | |
|---------------------|--------------------------|---|
| 1. tandem panel | ☐ | a. device that charges in seconds and delivers quick bursts of power |
| 2. electrolyser | ☐ | b. factory-built battery with a ceramic electrolyte, no flammable liquid |
| 3. solid-state cell | ☐ | c. software that lets a parked EV send energy back to the grid |
| 4. super-capacitor | ☐ | d. high-efficiency solar module with two light-absorbing layers |
| 5. micro-grid | ☐ | e. local network able to work with or without the main grid |
| 6. V2G system | ☐ | f. machine that produces green hydrogen by splitting water |

F. Choose the correct option (tick ✓ one)

1. What do charged particles create around themselves?
 - ☐ electric motors
 - ☐ electric fields
 - ☐ magnetic poles
 - ☐ heat engines
2. Which method now supplies most commercial electricity worldwide?
 - ☐ static electricity
 - ☐ electromagnetic induction
 - ☐ photovoltaic effect
 - ☐ thermoelectric effect
3. In a photovoltaic cell, light energy is directly converted into...
 - ☐ kinetic energy
 - ☐ chemical energy
 - ☐ electrical energy
 - ☐ nuclear energy
4. Which effect uses a temperature difference to generate a voltage?
 - ☐ piezo-electric
 - ☐ thermoelectric
 - ☐ electro-chemistry
 - ☐ static charge

5. Perovskite-silicon tandem panels are an improvement because they...
 - ☐ track the sun mechanically
 - ☐ capture a wider range of sunlight colours
 - ☐ contain no semiconductors
 - ☐ use heavy glass layers
6. A Small Modular Reactor (SMR) can follow solar output because it...
 - ☐ is cooled passively and built in a factory
 - ☐ burns natural gas
 - ☐ floats on the sea
 - ☐ stores electricity in batteries
7. Which storage device fills and empties in seconds and survives about a million cycles?
 - ☐ solid-state lithium cell
 - ☐ pumped-hydro plant
 - ☐ super-capacitor
 - ☐ sodium-ion battery
8. Vehicle-to-Grid (V2G) software allows a parked electric car to...
 - ☐ generate hydrogen gas
 - ☐ lend a few kilowatt-hours back to the grid
 - ☐ replace its lithium with sodium
 - ☐ drive without recharging
9. Pumped-hydro storage is often called a “water battery” because it...
 - ☐ freezes water into ice
 - ☐ uses water levels to store and release energy
 - ☐ burns water for heat
 - ☐ filters drinking water
10. Which new battery chemistry replaces costly lithium with common salt?
 - ☐ solid-state lithium
 - ☐ sodium-ion
 - ☐ lead-acid
 - ☐ nickel-metal hydride

Language Development



A. Fill in the blanks with the right form of the verbs

induce, alter or their derivatives:

1. I'm tired of my plans every time you change your mind.
2. We have no but to work.
3. The act or process by which an electric or magnetic effect is produced in an electrical conductor is called.....
4. An electric generator or dynamo producing alternating current is called.....
5. None of these measures a change of policy
6. In 1831, Michael Faraday showed that a moving magnet could an electric current in a wire - the basis of an electric generator.
7. An electric current that reverses direction in a circuit at regular intervals is an.....

B. Advanced Open Cloze *Read the text below about Triboelectric Nanogenerators (TENGs) and think of the word which best fits each gap. Use only ONE word in each gap.*

Harvesting Everyday Motion In 2012, researchers demonstrated that the very same rubbing action that gives us annoying static shocks **(1)** actually power tiny electronic devices. A triboelectric nanogenerator (TENG) is typically made of two thin plastic films. **(2)** these films touch and separate, electrons jump between them, creating a small alternating voltage. The potential of this technology is enormous. Today, TENGs can harvest the mechanical energy from the swing of a door **(3)** even the motion of ocean waves. They are capable **(4)** supplying continuous power to wireless sensors and medical wearables **(5)** the need for heavy batteries or moving metal parts.

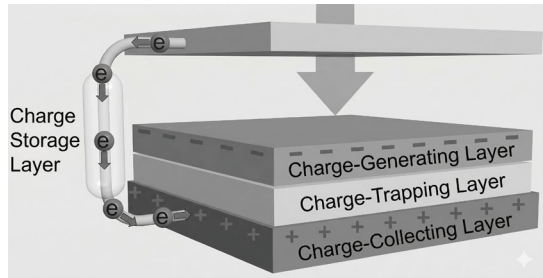


Going further

The triboelectric effect (also known as triboelectric charging) is a type of contact electrification in which certain materials become electrically charged after they come into frictional contact with a different material. Rubbing glass with fur, or a comb through the hair, can build up triboelectricity. Most everyday static electricity is triboelectric. The polarity and strength of the charges produced differ according to the materials, surface roughness, temperature, strain, and other properties.

Triboelectric Nanogenerators (TENGs)

In 2012 researchers in Georgia Tech showed that the same rubbing action that gives static shocks can power tiny devices. A triboelectric nanogenerator, or TENG, is made of two thin plastic films covered with micro-patterns. When the films touch and separate, electrons



jump between them and create a small alternating voltage. Thousands of these “static batteries” can be built on one postcard-sized sheet. TENGs now harvest the swing of a door, the vibration of a bridge or even the motion of ocean waves and supply milliwatts to wireless sensors, LED lights or medical wearables—without any heavy battery or moving metal parts.

****A Van de Graaff generator**

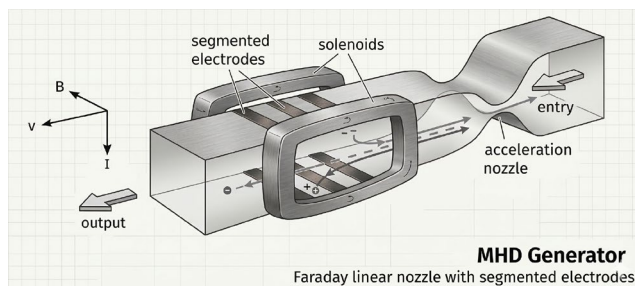
Is an electrostatic generator which uses a moving belt to accumulate electric charge on a hollow metal globe on the top of an insulated column, creating very high electric potentials. It produces very high voltage direct current (DC) electricity at low current levels. It was invented by American physicist Robert J. Van de Graaff in 1929.[1] The potential difference achieved in modern Van de Graaff generators can reach 5 megavolts. A tabletop version can produce on the order of 100,000 volts and can store enough energy to produce a visible spark. Small Van de Graaff machines are produced for entertainment, and in physics education to teach electrostatics; larger ones are displayed in science museums.



****MHD Generator**

A magnetohydrodynamic generator (MHD generator) is a magnetohydrodynamic device that transforms thermal energy and kinetic energy into electricity. MHD generators are different from traditional electric generators in that they operate at high temperatures without moving parts. MHD was developed because the hot exhaust gas of an MHD generator can heat the boilers of a steam power plant, increasing overall efficiency. MHD was developed as a topping cycle to increase the efficiency of electric generation, especially when burning coal or natural gas.

Modern MHD still faces challenges mainly high electrode wear and complex plasma chemistry but 2025 prototypes show that, with better magnets and ceramics, MHD can boost plant efficiency, reduce CO₂, and even operate on 100 % solar or hydrogen heat sources.



C. Grammar Focus: Verb Tenses (The Timeline of Energy) Complete the sentences by putting the verbs in parentheses into the correct tense (Past Simple, Past Continuous, Past Perfect, Present Simple, Present Perfect, or Future Simple).

1. In 1831, Michael Faraday (**show**) that a moving magnet could induce an electric current in a wire.
2. By the time Sir Charles Parsons invented the modern steam turbine in 1884, scientists (**already / discover**) the principles of electromagnetic induction.
3. Currently, the modern steam turbine (**generate**) about 80% of the electric power in the world.
4. Over the last five years, the technology behind renewable electricity (**change**) incredibly fast.
5. While the researchers at Georgia Tech (**test**) friction, they realized that the rubbing action could power tiny devices.
6. Experts predict that in the near future, surplus midday solar power

D. Vocabulary: Technical Collocations

Fill in the blanks with the right phrase:

Solid state battery, Vehicle-to-Grid (V2G) technology, electromagnetic induction

1. is the most widely used method for generating commercial electricity worldwide.
2. Parked electric cars can send energy back to the network during peak hours using

3. Instead of using a flammable liquid, a uses a thin ceramic material to store energy safely.

C. Vocabulary: The "Odd One Out" *In each group of technical terms below, one word does not belong to the same category as the others according to the text. Circle the odd one out and briefly explain why.*

1. **Photovoltaic / Thermoelectric / Piezoelectric / Fossil Fuel**

Reason:

2. **Lithium-ion / Sodium-ion / Van de Graaff / Super-capacitor**

Reason:

3. **Wind / Hydro / Tidal / Coal**

Reason: