# 9.3.3 Generators

Generators are used to provide large scale power production

## 3.1 Describe the **main components of a generator**

- **Magnetic field**: can be provided by a magnet, to create a magnetic field for loop to experience force
  - Can be **a stator** (stationary) or **rotor** (rotating magnetic field)
  - **Radial** magnet: constant rotation speed – angle remains 0° longer, and torque is maximum
- **Armature**: coil of wire inside magnetic field, to maximise torque as it is proportional to number of loops
  - It is **mechanically spun** in a generator, such as using steam to turn a turbine to rotate across the magnetic field
- **Split-ring commutator**: ring that **changes direction of current**
  - Changes **force directions** and therefore keeps motor spinning one direction
- **Carbon brushes**: conducts current in and out of the coil, as the commutator rotates

## 3.2 Compare the **structure and function of a generator** to an **electric motor**

- The structure is **the same**, but does not require **a source of power**, rather it requires supply of mechanical energy
- Function – **converts mechanical energy to electrical energy** trough electromagnetic induction
  - Therefore **creates power** (i.e. source of energy from fossil fuels, hydropower or wind)

## 3.3 Describe the differences between **AC and DC generators**

- Recall in a motor (and generator) that:
  - When flat and at 0°, **0 flux, maximum change in flux**, maximum EMF induced, maximum current
  - When vertical and at 90°, **max flux, min change in flux**, min EMF and current induced
  - Note the **difference between flux and change in flux**
- Difference between DC and AC is the commutator
- **DC generator** (split ring commutator)
  - When rotating from 0°, maximum current is induced (use right hand palm rule)
  - When approaching 90°, minimum current induced, but the **commutator will switch** and therefore **keep generating current in the same direction (i.e. DC current)**

COOL GRAPH AND TWO GENERATOR IMAGES

- **AC generator** (slip ring commutator)
  - When rotating from 0°, maximum current is induced (use right hand palm rule)
  - When approaching 90°, minimum current induced, but as the armature keeps spinning, no current switches and therefore the current **switches direction**
    - Creates an **alternating current**, frequency based on speed of rotation

COOL GRAPH AND TWO GENERATOR IMAGES

3.4 Discuss the **energy losses** that occur as energy is fed through **transmission lines** from the **generator to the consumer**

- Resistance causes production of **heat** in transmission lines

$$P = I^2R$$

Where P = heat lost (J), I = current (A), R = resistance (Ω)
Derived from $P = IV$ and $V = IR$

- Transformers to change voltage also causes heat loss (less for AC than DC, see 9.3.5)

3.5 Assess the **effects of the development of AC generators** on society and the environment

BENEFICIAL EFFECTS OF DEVELOPMENT OF AC GENERATORS

- Widespread application of AC electricity **domestically and industrially**
- **Simpler and cheaper** to build AC generators
    - Efficient compared to previous sources of power (diesel, fuel, wood)
    - Cheaply transmitted over great distances with less loss than DC
- Since **easy to transmit**, power plants can be **situated far away from** energy consumption
    - Shifts pollution away from homes or workplaces
- Has stimulated the development of industry

DETRIMENTAL EFFECTS OF DEVELOPMENT OF AC GENERATORS

- **Environmental effects** of growth in electricity industry
    - Visual pollution of power transmission lines
    - Remote areas set up for tapping energy resources – disturbance to natural habitats
    - Air pollution from burning fossil fuels as a cause of acid rain
    - Nuclear power stations leave radioactive waste that lasts for many years
- **Over-reliance on AC** power – if a widespread failure of electricity occurs, economic crisis, or accidents
- Replacement of labour

3.P1 Plan, choose equipment or resources for, and perform a first-hand investigation to demonstrate the **production of an alternating current**

- A coil was moved up and down with a magnet entering and exiting the coil.
    - A galvanometer was connected to the coil, and the needle moved back and forth

3.P2 Gather secondary information to discuss **advantages/disadvantages of AC and DC generators** and relate these to **their use**

ADVANTAGES OF DC GENERATORS

- Some devices require DC currents, such as **battery rechargers and cathode ray tubes**
    - More efficient to generate DC current than switch AC to DC
- For a given voltage, **DC current is more powerful than AC current**

DISADVANTAGES OF DC GENERATORS

- Requires a **split ring commutator** – more expensive **construction**, more cost and effort for **maintenance**
    - Gap in the split ring produces sparks
- Output of DC generators **lose more energy** in transmission

ADVANTAGES OF AC GENERATORS

- **Lose less energy** in transmission than DC generators
- Uses a **slip ring commutator** – continuous smooth surface
- Three-phase AC currents can be made, and can power **induction motors**

DISADVANTAGES OF AC GENERATORS

- Frequencies of AC generators in different regions must be **synchronised** and in phase
- **10 times more dangerous** than DC generator output – heart fibrillation

3.P3 Analyse secondary information on the **competition between Westinghouse and Edison** to **supply electricity to cities**

- Edison set up a **DC based** supply of electricity **in 1878**
    - Was well established and worked well with short distances
- Westinghouse bought a tenant off Tesla for AC system
    - Opened an **AC based** supply of electricity **in 1885**
    - More suitable as voltage can be **stepped up or down using transformers** and also induction motor
    - SSmaller energy losses over long distances
- Edison had a vested interest in DC, and proved AC was dangerous by electrocution of animals
- Competition to supply energy in 1886 for **power plant using Niagara Falls**
    - Westinghouse won the competition

3.P4 Gather and analyse information to identify how **transmission lines** are:

**INSULATED** FROM SUPPORTING STRUCTURES

- High voltage transmission lines are kept away from supporting structures using **insulation**
    - Prevents metal towers from becoming live, and prevents short circuiting
- Insulated using **stacks of disks made from ceramic, porcelain or rubber (with fibre glass core)**
    - Strong and retains insulation properties under high voltage
    - Water and dust prevented from building up
    - Disc shape to ensure longer pathway

PROTECTED FROM **LIGHTNING STRIKES**

- Wire **running over the top** of transmission wires connected to earth
    - Wire carries lightning current and diverts it to the earth
- Prevents **damage or overload** to transformers, wires or power poles