The National Grid

6.2.4.3 · Physics · revision notes

The National Grid is the system of cables and transformers that links power stations to consumers. You need to know what step-up and step-down transformers do, and to explain why transmitting at a high potential difference is an efficient way to transfer energy. Expect 2 to 4 mark 'explain' questions and some power calculations.

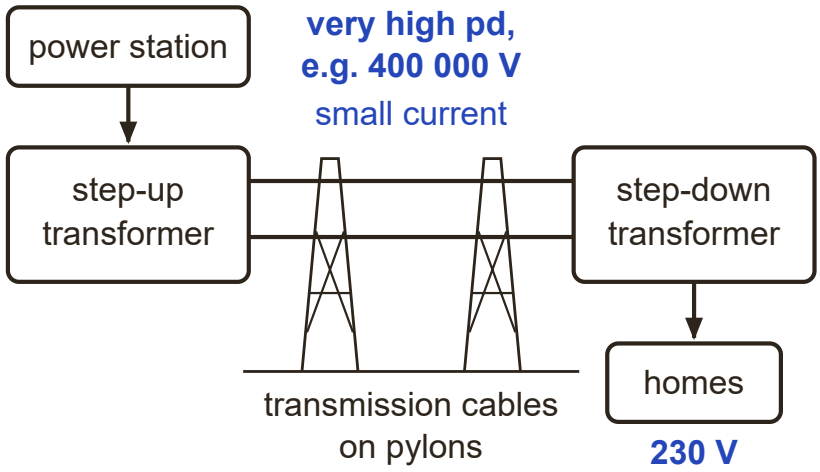
Key facts

- National Grid = cables + transformers linking power stations to consumers
- Step-down transformer: decreases the pd (transmission cables → homes, about 230 V)
- Heating loss in cables: $P = I^2 R$
- Step-up transformer: increases the pd (power station → transmission cables)
- $P = V I$: higher pd → lower current for the same power
- Lower current → less heating → less energy wasted → more efficient

Notes

What the National Grid is

- The National Grid is a system of **cables** and **transformers** that links power stations to consumers (homes, schools, offices and factories).
- Electrical power is transferred from power stations to consumers using the National Grid.
- Order: power station → step-up transformer → transmission cables → step-down transformer → consumers.



The National Grid: step up the pd for the cables, step down for homes.

Transformers

- **Step-up transformers** increase the potential difference from the power station to the transmission cables, to a very high value (hundreds of thousands of volts).
- **Step-down transformers** decrease the potential difference to a much lower value (about 230 V) for domestic use.
- Such a high pd would be far too dangerous in homes, which is why it is stepped down before it reaches consumers.

Why a high pd is efficient

- For a given power, $P = V I$. If the pd is increased, a smaller current is needed to transfer the same power.
- The transmission cables have resistance, so a current in them heats them. The power wasted by heating is $P = I^2 R$.
- A smaller current means much less energy is transferred to the thermal energy store of the cables and surroundings. Less energy is wasted, so more reaches consumers and the transfer is more efficient.
- The heating loss depends on the current **squared**, so halving the current cuts the heating loss to a quarter.

Grade 7+ only

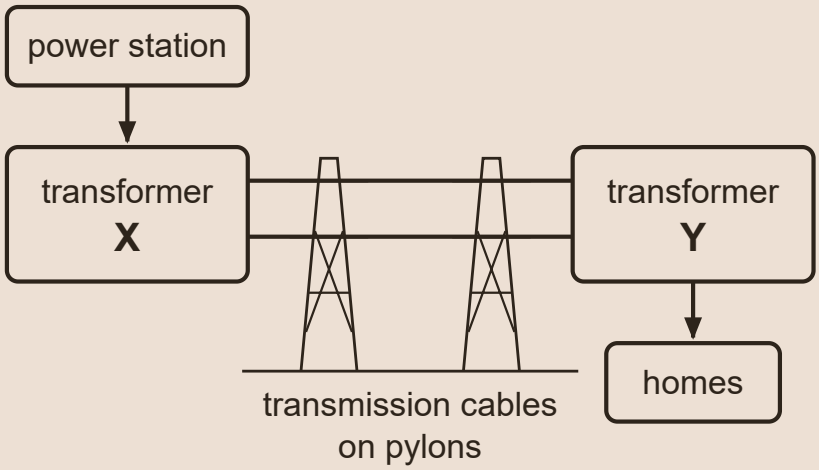
How to answer each type of question

Name or describe the transformers

1 to 2 marks | **Grade 4**

1. Transformer next to the power station: step-up, increases the pd.
2. Transformer next to the consumers: step-down, decreases the pd.
3. Say what happens to the pd, not just the name, if asked to describe.

Example. In the National Grid, transformer X is between the power station and the transmission cables. Transformer Y is between the transmission cables and the homes.



(a) Name the type of transformer X.
(b) Describe what transformer Y does.

Model answer.

(a) Step-up (transformer) (1)
(b) It decreases the potential difference (to a much lower value, about 230 V, for use in homes) (1)

Explain why the National Grid uses a very high pd

3 to 4 marks | **Grade 5**

1. High pd means a low current for the same power ($P = V\,I$).
2. Low current means less heating of the cables ($P = I^2\,R$).
3. So less energy is wasted to the surroundings.
4. So the National Grid is an efficient way to transfer energy.

Example. Explain why electrical power is transmitted through the National Grid at a very high potential difference.

Model answer. For the same power, a higher potential difference means a smaller current (1). A smaller current means less heating of the transmission cables (1). So less energy is transferred (wasted) to the surroundings (1). So the energy transfer is more efficient / more energy reaches consumers (1).

Calculate the current and the power wasted in the cables

4 to 5 marks | Grade 8

1. Convert MW to W and kV to V.
2. Find the current in the cables with $I = P \div V$.
3. Find the power wasted with $P = I^2 R$, using the resistance of the cables.

Example. A power station transfers 100 MW of power to the transmission cables at a potential difference of 400 kV. The cables have a total resistance of 20 Ω.
(a) Calculate the current in the cables.
(b) Calculate the power wasted by heating the cables.

Model answer.

(a) $I = P \div V = 100\,000\,000 \div 400\,000$ (1)

$I = 250$ A (1)

(b) $P = I^2 R = 250^2 \times 20$ (1)

$P = 1\,250\,000$ W (1.25 MW) (1)

Don't lose marks

- Saying a high pd 'makes the electricity travel faster' or 'reduces the resistance'. It reduces the current.
- Saying a step-up transformer increases the power. It increases the pd; the current in the cables is smaller.
- Stopping at 'the current is lower' without saying what that does: less heating of the cables, so less energy wasted.
- Mixing up where the step-up and step-down transformers go.
- Saying a high pd means 'no energy is lost'. Some energy is still transferred by heating the cables: say 'less energy is lost'.

More tips

Memory tricks

- Step UP the pd and the current goes DOWN: the grid trades a high pd for a low current.
- 'High volts, low amps, low losses.'
- Order of the grid: power station → UP → cables → DOWN → homes.

Exam technique

- For 'explain' questions, build the chain: high pd → low current → less heating in the cables → less energy wasted → efficient.
- Use the word 'efficient' and say where the wasted energy goes (the thermal energy store of the cables and surroundings).
- In calculations, convert MW to W (× 1 000 000) and kV to V (× 1000) before using $P = V I$.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3

Describe what the National Grid is

A system of cables and transformers linking power stations to consumers.

Grade 4

State what a step-up transformer does

It increases the potential difference from the power station to the transmission cables.

Grade 4

State what a step-down transformer does

It decreases the potential difference to a much lower value for domestic use.

Grade 5

Explain why a high pd means low current

For the same power, P = V I, so increasing the pd decreases the current.

Grade 5

Explain why the National Grid is efficient

A lower current means less heating of the cables, so less energy is wasted.

Grade 8

Calculate power wasted in transmission cables

Find the current with I = P ÷ V, then the heating loss with P = I^2 R.

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