

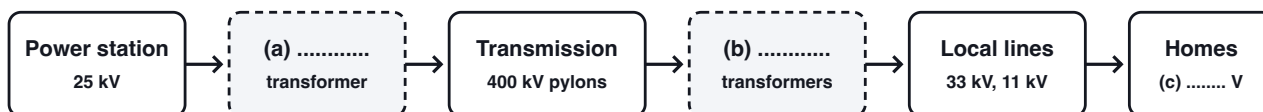
The National Grid

Name: _____ Class: _____ Date: _____

Power = current × voltage: $P = I \times V$, so $I = P \div V$. **Power wasted heating a wire:** $P = I^2 \times R$.
 1 kV = 1,000 V · 1 MW = 1,000,000 W · 1 kW = 1,000 W

Part A · From power station to home

A1 This diagram shows how electricity gets from a power station to a home.



- a) and b) Write **step-up** or **step-down** in the gaps (a) and (b). [2]
 c) What voltage do homes in the UK use? [1]

A2 In **Switch On**, the village of Ashby takes 0.8 MW at 11 kV. Work out the current it takes. [2]

A3 In **Far Away Farm**, the farm needs 2 MW.

- a) What current would an 11 kV line need to carry? [1]

- b) What current would a 33 kV line need to carry? [1]

- c) The 33 kV line is 40 km long and has a resistance of 12 Ω . Use $P = I^2 \times R$ to work out the power wasted heating it. [2]

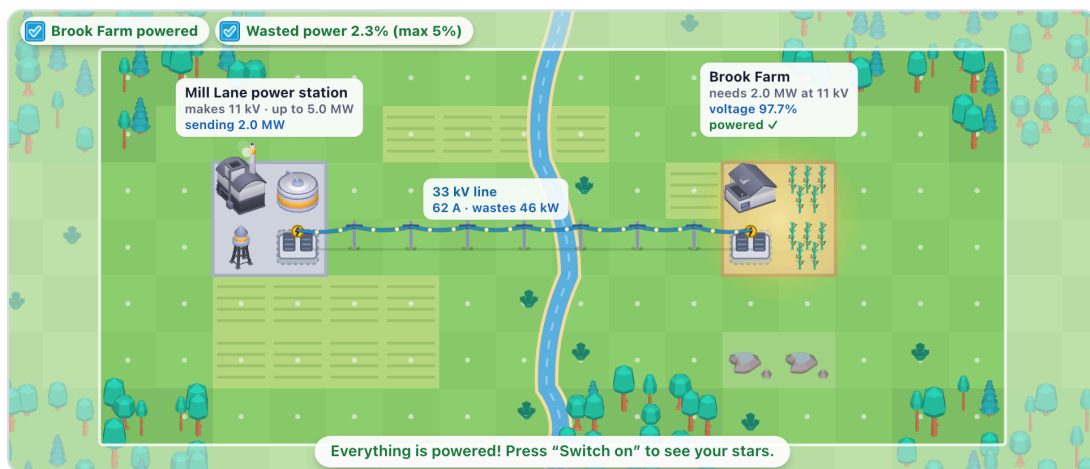
- d) Tripling the voltage cuts the current to a third. How many times smaller does that make the power wasted? [1]

Part B · Play levels 1 to 4

Before you build, use $P = I \times V$ to predict the current. Record your best design for each level.

Level	Voltages used	Transformers	Cost	Stars	What went wrong, and how I fixed it
1			£ m		
2			£ m		
3			£ m		
4			£ m		

Part C · Read the numbers



C1 This is **Far Away Farm** with a 33 kV line and **Numbers** on. Read the current in the line and the power it wastes. The station sends out 2,046 kW: what percentage is wasted? [3]

C2 Brook Farm gets 97.7% of its voltage, not 100%. Explain why. [2]

Part D · Explain

D1 Explain how the National Grid uses transformers to get electricity to homes efficiently and safely. Use the words *current*, *voltage* and *energy wasted*. [4]

Losses, ratings and network design

Name: _____

Class: _____

Date: _____

$P = I \times V$ · $P = I^2 \times R$ · $V = I \times R$ · ideal transformer: $V_p \times I_p = V_s \times I_s$ and $V_p \div V_s = N_p \div N_s$
Each map square is 5 km. Resistance per square: 33 kV line 1.5 Ω · 132 kV line 0.5 Ω · 400 kV line 0.1 Ω

1 Step Up, Step Down. Riverton needs 30 MW. It is 10 squares (50 km) from the power station.

a) What current would a 33 kV line carry? [1]

b) A 33 kV line is only safe up to 400 A. What would happen to it? [1]

c) What current would a 132 kV line carry? [1]

d) Work out the resistance of the 132 kV line, the power wasted in it, and that power as a percentage of 30 MW. [3]

2 Transformers. The power station's step-up transformer changes 25 kV into 132 kV.

a) Its primary coil has 1,000 turns. How many turns does the secondary coil need? [2]

b) 30.3 MW goes into the transformer. Assuming it's ideal, work out the current in the primary coil and in the secondary coil. [2]

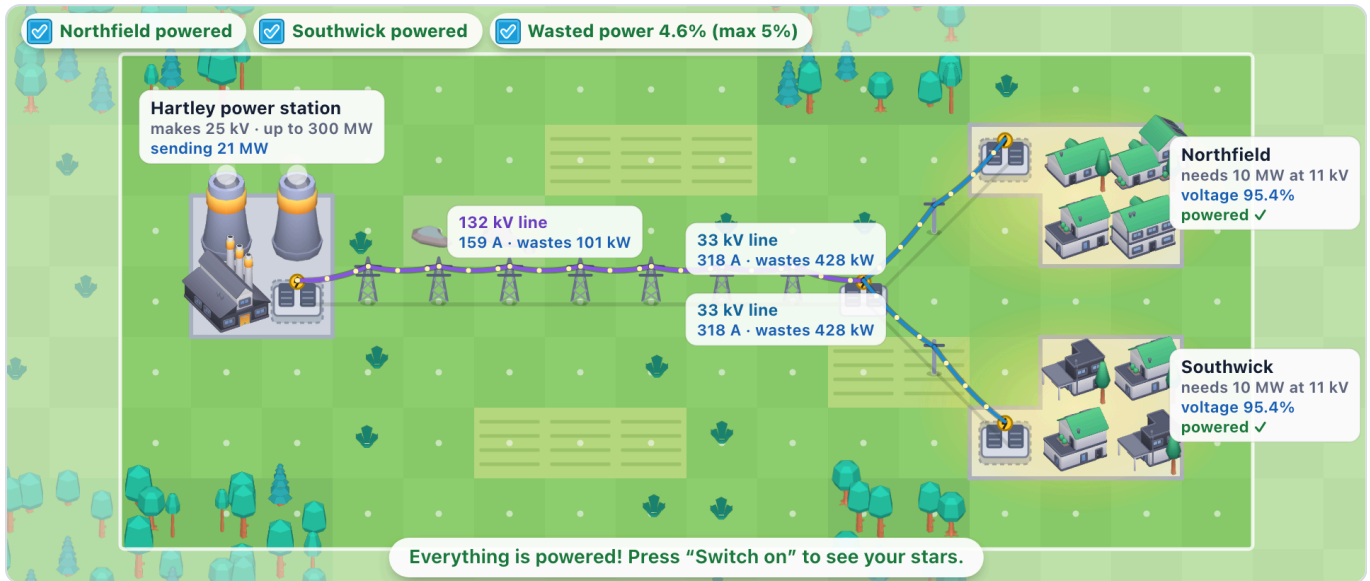
3 The Steelworks needs 150 MW. A 132 kV line is rated at 800 A.

a) Work out the current in a 132 kV line. Can it be used? [2]

b) The game shows 1,178 A in the 132 kV line, a bit more than your answer. Suggest why. [2]

c) What current would a 400 kV line carry? [1]

4 Two Towns. One 132 kV line runs from the power station to a substation, where a transformer feeds a 33 kV branch to each town. Each town needs 10 MW.



a) Use the figure to show that the power going into the substation is about the same as the power coming out. [2]

b) Which lines waste the most power? Explain why. [2]

c) An engineer suggests 132 kV lines all the way to both towns: £92m and 0.5% wasted, instead of £80m and 4.6% wasted. Give one argument for and one against. [2]

5 The National Park. 132 kV costs £5m per square overhead, and £20m per square as underground cable. Each transformer costs £8m.

a) One design goes straight through the park: 4 squares overhead and 7 squares of underground cable, with two transformers. Work out its cost. [2]

b) The 3-star design costs £124m by crossing the park where it's narrowest. Give two reasons why engineers sometimes pay for underground cables anyway. [2]

[6]

Plan your answer first. For each idea, note the evidence from the game and whether it's an advantage or a disadvantage.

Idea	Evidence from Power Lines (numbers or levels)	Advantage or disadvantage?
Current		
Energy losses		
Cost		
Safety and environment		

Now write your answer, finishing with a conclusion.