

Solutions

2.1 The National Grid; a step-up transformer and a step-down transformer.

2.2 It increases (steps up) the potential difference; it is placed between the power station and the transmission cables.

2.3 The wasted power falls to **one quarter**; $P = I^2R$: the resistance is unchanged, so halving I quarters I^2 and hence the wasted power.

3.1 (a) The step-up transformer raises the potential difference for transmission; for the same transmitted power $P = VI$, the higher potential difference means a smaller current in the cables; the power wasted by heating the cables is $P = I^2R$; a smaller current wastes much less energy in the cables, so the transfer is more efficient. (b) Homes need a low, safe potential difference (about 230 V) for appliances; the step-down transformer reduces the very high transmission potential difference to the domestic value.

3.2 (a)

$$P = I^2R = (2000 \text{ A})^2 \times 40 \text{ } \Omega = \mathbf{1.6 \times 10^8 \text{ W}}$$

(C1, A1 with unit.) (b)

$$P = (500)^2 \times 40 = 2.5 \times 10^5 \times 40 = \mathbf{1.0 \times 10^7 \text{ W}}$$

(C1, A1.) (c) Cutting the current to a quarter (for the same delivered power, at higher pd) cut the wasted power to one sixteenth; only a small fraction of the transmitted energy is lost to cable heating, which is what makes the Grid efficient.

3.3 (a) At the higher potential difference the current in the line is smaller, because the delivered power obeys $P = VI$ – for the same power, larger V means smaller I ; the line's wasted power is $P = I^2R$ with fixed R ; so the 400 kV line wastes far less energy as heat – $(132/400)^2 \approx 11\%$ of the 132 kV line's loss at the same delivered power. (b) Any one: very high potential difference needs taller pylons, wider safety clearances and more insulation – near homes that is costly and harder to make safe; lower pd reduces the danger and cost of the local section even though losses rise over a short distance.