On electricity supply

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Warm-up problems

1. [AQA June 2013 Q 1 d i] Complete the sentence: 'The national grid is...'

   (a) a system of cables and pylons

   (b) a system of cables and transformers

   (c) a system of cables, transformers and power stations

2. [AQA June 2013 Q 6 a i] In the UK, over 70% of the electricity is generated in power stations that burn fossil fuels. Explain one effect that burning fossil fuels has on the environment, and give one way the effect on the environment could be reduced (assume the amount of fossil fuels burnt stays the same).

3. The equation

$$\text{Power} = \frac{\text{Energy}}{\text{time}}$$

   is commonly be used with two sets of units. Write down both sets of units, and show that $1\,\text{kWh} = 3\,600\,000\,\text{J}$

Regular problems

4. Calculate the amount of electrical energy used by the following electrical appliances (the UK average tariff for electricity[1] works out at 15.2 p/kWh):

   (a) A 2 kW heater which is left on for 4 hours,

   (b) A kettle of power rating 1.4 kW takes 5 minutes to boil a litre of water,

   (c) A 40 W lightbulb is left on for a whole day (24 hours).

5. In a power station, a boiler which is 80% efficient converts water into steam to drive a 50%-efficient turbine, which in turn operates a generator of efficiency 90% to transfer kinetic energy into electrical energy.

   (a) For every 1000 J of chemical energy input to the boiler how much electrical energy is supplied by this power station to the national grid?

   (b) What is the overall efficiency of the power station?

   (c) Draw a Sankey diagram to show the energy flows in this power station.

6. [AQA January 2012 Q 8 a] Nuclear fuels and the wind are two of the energy sources used to generate electricity in the UK. Explain the advantages of using energy from nuclear fuels to generate electricity rather than using energy from the wind. Include in your answer a brief description of the process used to generate electricity from nuclear fuels.

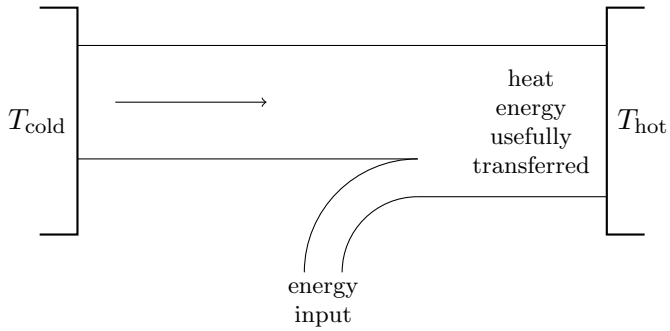
[1] Source: sust-it.net, September 2014

7. [AQA January 2013 Q 6 d] Electricity is distributed from power stations to consumers along the National Grid. The voltage across the overhead cables of the National Grid needs to be much higher than the output voltage from the power station generators. Explain why.

Extension problems

8. It is often said that we use too much energy (sometimes there is talk of an 'energy crisis' if the energy supply cannot match up to the demand). If energy cannot be created or destroyed, how can we 'use up' energy? Why isn't it possible to keep 'using' the same energy over and over again?

9. A heat pump is a device that pumps heat energy from a place at a low temperature T_{cold} to a place with a higher temperature T_{hot}. An example is a refrigerator, where the heat is pumped from the inside of the fridge to the outside.



For an ideal heat pump, it can be shown that the 'efficiency'[2] is given by

$$\frac{T_{\text{hot}}}{T_{\text{hot}} - T_{\text{cold}}} (\times 100\%).$$

(a) Calculate the 'efficiency' of a heat pump used to heat a house to 297 K (24 °C) in winter, if the outside temperature is 277 K (4 °C) on average.

(b) If 300 J of electrical energy is used by such a heat pump, how much heat energy is usefully pumped into the house, and *how much is taken from the outside?

(c) What is the efficiency of the heat pump if there is no temperature difference between the inside and the outside? Comment on your result!

[2]For heat pumps the ratio of the usefully energy transferred to the input energy is usually called the *coefficient of performance (CoP)* instead of the efficiency.