Teaching ideas for Topic 7: *Energy, power and climate change*, Core

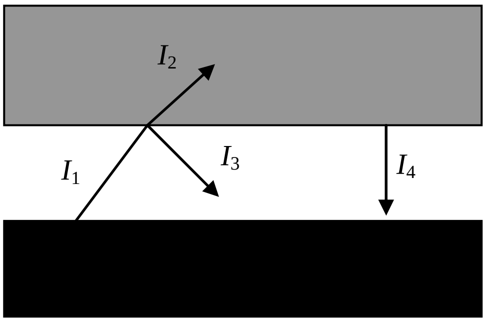
Questions

A number of worksheets are provided for this Topic:

- support questions examine the very basic concepts of the syllabus
- extended questions delve deeper and are equivalent to exam level questions.

Teaching ideas

- A useful activity is to ask students to research how electricity is produced in their country (what percentage is obtained from coal, gas, nuclear, etc.). They can then compare their data with world averages.
- There are essentially two distinct parts to this topic – power production and climate change. The power production part is easy to teach as there are many repetitive statements that need to be made, for example listing 'advantages' and 'disadvantages' of the various methods.
- Students must be able to derive the formulae for power produced in
  (1) windmills
  (2) wave generators, assuming a square profile, and
  (3) hydropower.
- The following is a useful exercise to get students to understand thermal equilibrium in the context of radiated power, but also to see the different way that black bodies and grey bodies behave:
  The diagram shows a black body of temperature T_1 emitting radiation towards a grey body of lower temperature T_2 and emissivity e. No radiation gets transmitted through the grey body



  Using all or some of the symbols T_1, T_2, e and σ, state expressions for the intensities I_1, I_2, I_3 and I_4, explaining your work.
  Answers are: $I_1 = \sigma T_1^4$ because we have a black body of emissivity 1. $I_2 = e\sigma T_1^4$ since a grey body of emissivity e absorbs a fraction e of the intensity incident upon it. $I_3 = \alpha\sigma T_1^4$; this is intensity reflected, where α is the albedo. Here, since no radiation gets transmitted through the grey body $\alpha = 1 - e$ and so $I_3 = (1 - e)\sigma T_1^4$. Finally, $I_4 = e\sigma T_2^4$ because the grey body has emissivity e.
- It is very instructive to do the above exercise. Then ask about the net intensity *leaving* the black body. This is $I_1 - I_3 - I_4 = \sigma T_1^4 - (1 - e)\sigma T_1^4 - e\sigma T_2^4 = e\sigma(T_1^4 - T_2^4)$. This means that for equilibrium, the two temperatures must be the same. You can now also do past exam questions with students on the equilibrium temperature of the Earth. They will see that in many examples intensities such as the reflected intensity I_3 are neglected, so students must be very careful with these exam models because most are physically unrealistic.

Practical activities/ICT

- The simulation http://phet.colorado.edu/en/simulation/blackbody-spectrum allows you to play with the black body spectrum curve.
- A simulation of the greenhouse effect, the effect of greenhouse concentrations and clouds can be seen at http://phet.colorado.edu/en/simulation/greenhouse
- The simulation http://phet.colorado.edu/en/simulation/microwaves has water molecules being irradiated with microwave radiation of variable frequency. It models absorption of radiation and excitation of the water molecules.
- There are many sites for simulations of climate change with varying degrees of sophistication and complexity and demanding small or very large amounts of computer time. Relatively simple simulations to predict future temperature increases, sea level changes, etc. by varying a reasonably small set of parameters can be performed at: http://forio.com/simulation/climate-development/

Common problems

- Students are generally comfortable with the first part of this topic (energy and power production), but often get confused on the climate change/black body radiation part of the topic. Some confusing past examination questions on this topic have not helped. It is important to give clear and physically consistent examples so students can practice energy balance calculations. Care must be taken not to give examples where a body radiates like a black body yet it is given an albedo! An easy way out is to give examples in which the surface acts as a black body and the albedo is in the atmosphere. It is always good to finish these examples by asking the student to list the assumptions made in the calculation.

Theory of knowledge (TOK)

- An interesting TOK connection with this topic is perhaps the need for society to take action on a problem that, while scientific in nature, has become cloaked in political ideology. So much so that it becomes difficult to distinguish scientific fact from political propaganda. How does society act in light of conflicting information? Who gets trusted and who does not? There are ethical issues here as well: developed countries (which in the past, and in some cases even now, contributed enormously to greenhouse concentrations in the atmosphere) now demand smaller emissions from developing countries. Is this ethical or even fair?