08 Energy production answers

Sources and production

1. Real thermodynamic processes are not 100% efficient. Some of the energy becomes spread and is less useful. This non-recoverable energy is referred to as degraded energy?

(a) Draw a labeled diagram of a wind generator.

(b) Construct a Sankey (energy flow) diagram for a wind generator and identify the points where energy is degraded.

(c) If the air density is 1.25 kgm^{-3} and the wind speed is 10ms^{-1} what power is available to a wind turbine of blade length 20m?

2. The table shows energy density of potential fuels: (http://en.wikipedia.org)

Fuel	Used in	Specific energy obtained (MJ/kg)
Deuterium-Tritium mix	Nuclear fusion	567,000,000
Enriched Uranium (3.5% U-235)	Nuclear fission	3,456,000
Zip fuel (/wiki/Zip_fuel)	Jet engines	70
Kerosene	Jet engine	45
Coal	Power stations	30

Use the data to answer the following questions.

(a) Why, given the difficult technological barriers, is there still much interest and investment in nuclear fusion: **Nuclear fusion has the highest specific energy value so potentially the least amount of fuel needed.**

(b) Why, despite the risks, are many countries developing nuclear fission reactors? **Nuclear fission has a much higher specific energy value compared to the fossil fuels so much less fuel is needed.**

(c) It takes approximately 33MJ/kg to put a satellite into orbit. Why does this make it worthwhile developing Zip fuels with higher specific energies than Kerosene? **Each kg of kerosene provide 45-33 = 12MJ of energy above the energy required to put itself in orbit. (If you factor in the mass of the fuel container this figure will be reduced). If a fuel can be developed with a higher specific energy the mass of the fuel required reduces significantly**

(d) How many kg of coal does a 1000 MW **coal** plant that averages 750 MW of production over the course of day use in one day?

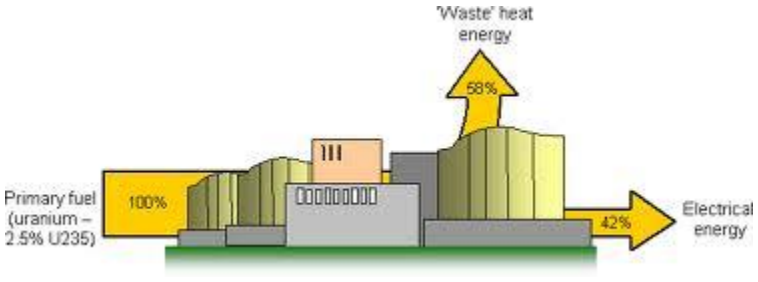
Energy [MJ] = Power [MW] x Time [s] = 750 x 24x60x60 = 64,800,000 MJ

Mass used = Energy / Specific energy = 64800000 / 30 = 2160,000 = 2.2x10^6 kg

(2200 tons)

3. Nuclear fission:

a. Construct a Sankey (energy flow) diagram for a nuclear power station treating the power station as a single process.

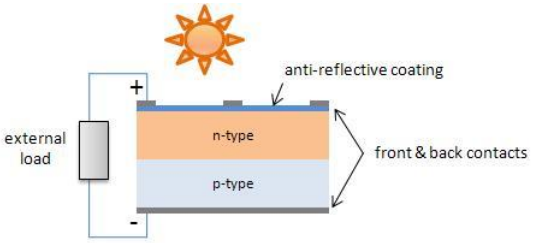


Identify a process within the power station where the most energy is degraded?
The conversion of energy into kinetic energy by the turbine. (The most energy is wasted in exhaust gases of the turbine).

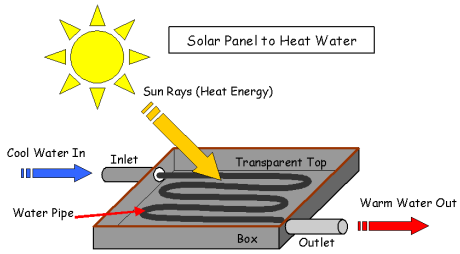
b. Explain how control rods and moderators help the nuclear chain reaction propagate safely in a nuclear reactor.
The moderator (water) slows the neutrons down so that the chain reaction continues in a stable fashion. Control rods absorb neutrons to reduce the rate of the reaction.

c. To keep the risk of contamination low the water that powers the turbines does not enter the reaction chamber. State which device is used to transfer the energy from the reaction chamber to the water.
Heat exchanger

4. What environmental problems are caused by the burning of fossil fuels? **Air pollution and increased levels of carbon dioxide**

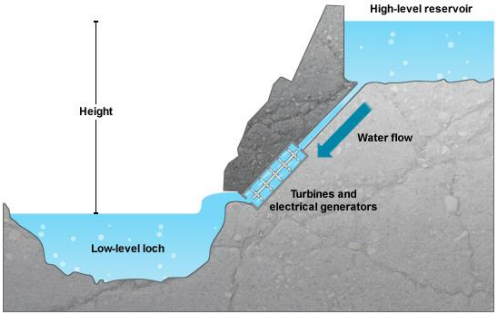


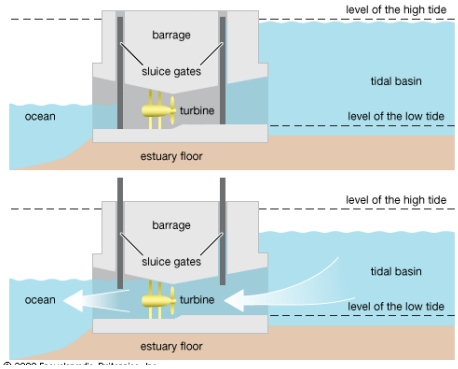
5. Draw a labeled diagram of a photo-voltaic cell.
6. Draw a labeled diagram of a solar heating panel.



7. Water power:
Draw diagrams to show the differences between the following hydro-electric power schemes.

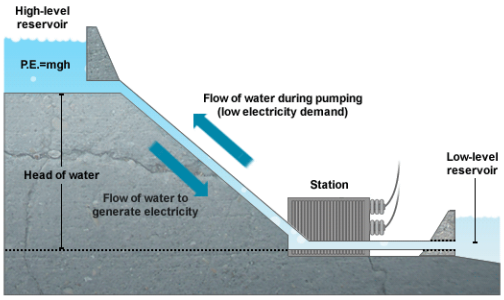
(a) water storage in lakes
(b) tidal water storage
(c) pumped water storage and give an advantage and disadvantage for each one.
Lake storage:
+ Clean, renewable
- Not possible in many locations or else the constructions of the dam floods large areas of land





Tidal
+ Clean, Renewable
- Only works for about an hour or two every six hours, large construction often needed, can affect the estuary environment

Pumped storage:
+ Energy available quickly
- Energy needed to pump water back up.



Thermal energy transfer

The sun has a luminosity of 3.8×10^{26} W. 1 AU = $1.5\text{x}10^{11}$ m. Radius of Earth = 6380km. The surface area of a sphere is $4\pi r^2$.

1. (a) Calculate the intensity of sunlight incident on the Earth

   By the time the radiation reaches the earth the power has spread over an area the size of the sphere around the sun with a radius equal to the distance to the Earth.

   $I = P/A = P/4\pi d^2 = 3.8\times10^{26}$ W / $4\pi(1.5\text{x}10^{11}\text{m})^2 = 1340\text{W/m}^2$

   (b) Calculate the total solar power reaching the Earth.

   Exposed are is equivalent to the area of a circle of Earth's diameter

   $= \pi \text{ x } (6.38\text{x}10^6)^2 = 1.28 \text{ x } 10^{14}\text{m}^2$

   $P = IA = 1340\text{x}1.28 \text{ x } 10^{14}\text{m} = 1.71 \text{ x } 10^{17}\text{W}$

   (c)Define albedo.

Albedo is the ratio of reflected radiation from the surface to incident radiation upon it.
(It is a reflection coefficient, [derived from Latin albus "white,"])

(d) State what meterological features increase the albedo of the Earth.

Clouds

(e) The average albedo is 0.3. Calculate the energy absorbed in 24 hours.

0.3 is reflected so 0.7 is absorbed.

$1.71 \text{ x } 10^{17}\text{W x } 0.7 \text{ x } 24 \text{ x } 60 \text{ x } 60 = 1.04 \text{ x}10^{22}\text{J}$

2. The average temperature of the Earth is 15^0C and its emissivity is approximately 0.6.

   (a) Calculate the power of radiation emitted from the surface of the Earth.

   The surface area of the Earth is $4\pi r^2 = 4\pi\text{x}(6.38\text{x}10^6)^2 = 5.12\text{x}10^{14}\text{m}^2$

   Temperature = 273 + 15 = 288K

   $P = \sigma AT^4$ [W]

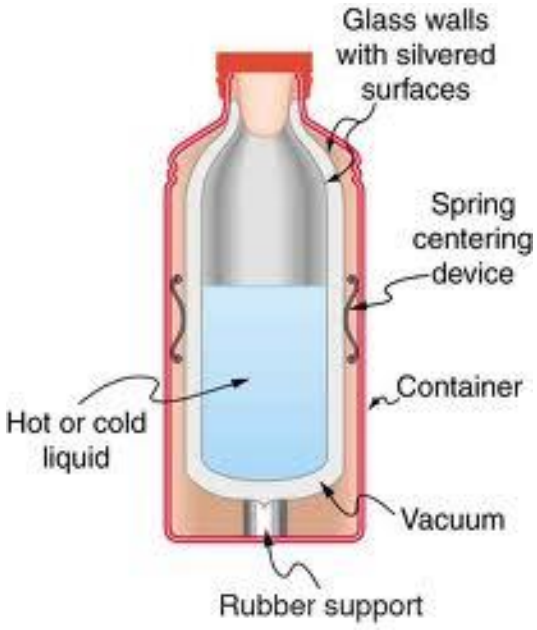
   $= 5.67 \times10^{-8} \text{ x } 5.12\text{x}10^{14} \text{ x } 288^4 = 2.0 \text{ x } 10^{17}\text{W}$

   (b) Explain, in terms of variation of absorbencies with wavelength of radiation, why "greenhouse" gases act to insulate the Earth.

3. The level of carbon di-oxide in the atmosphere is increasing. (a) What activities of humans have been directly increasing the amount in the atmosphere? **Burning of fossil fuels** (b) Explain how deforestation also increases the amount of carbon dioxide in the atmosphere. **Less forest means less photosynthesis which means less carbon dioxide is being absorbed from the atmosphere.**

4. The thermos flask on the right is designed to prevent heat transfer. Explain how the different insulating elements help to reduce the heat transfer. Use the words conduction, convection and thermal radiation in your answer.

The vacuum in between the glass walls prevents heat transfer by conduction or convection occurring except at the top of the flask. The silvered surfaces reflect the majority of the thermal radiation back the way it came. The stopper at the top of the flask prevents convection from the top of the flask and is made from an insulating material so the conduction is minimised.



http://fuyusa ma.blogspot.co.uk/2013_05_01_archive.html