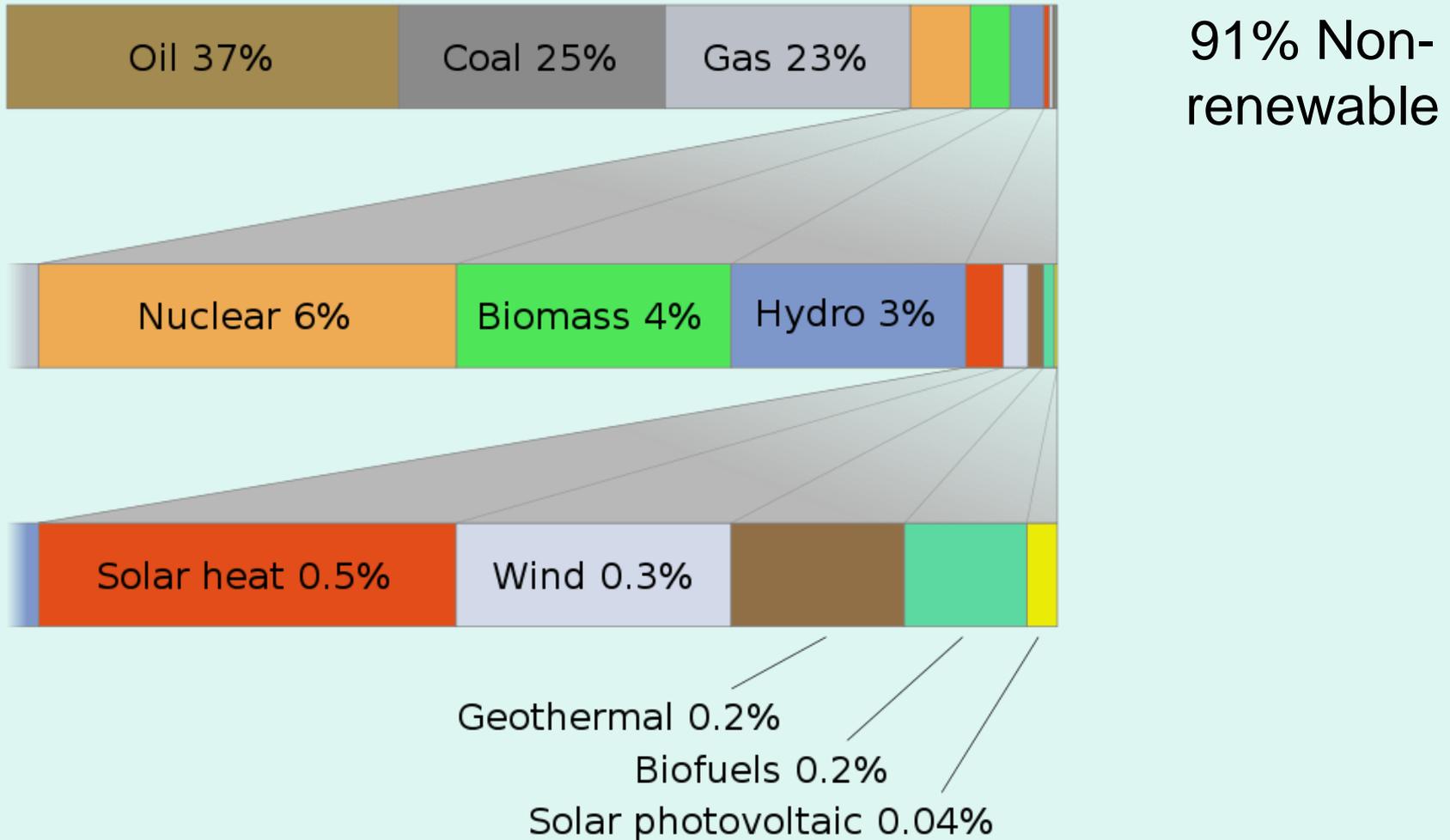


IB Topic 8.1: Energy Production, Energy Sources



World use of energy sources



Only approximate values are needed

Energy density of fuels

• Energy in	MJ/kg
• Uranium 235	90,000,000
• Crude Oil	41.9
• Coal	32.5
• Wood	17.0
• Petrol	46.9
• Cow dung	15.5

Considerations of energy density

- Transport costs
- Storage
- Applications e.g. Nuclear submarines



CO₂ emissions

- Emission indices (Kg CO₂/GJ)

- LPG 60
- Natural Gas 58
- Crude Oil 76
- Coal (electricity) 290

Production of electrical power



1. Heat source

2. Steam generation

3. Turbines

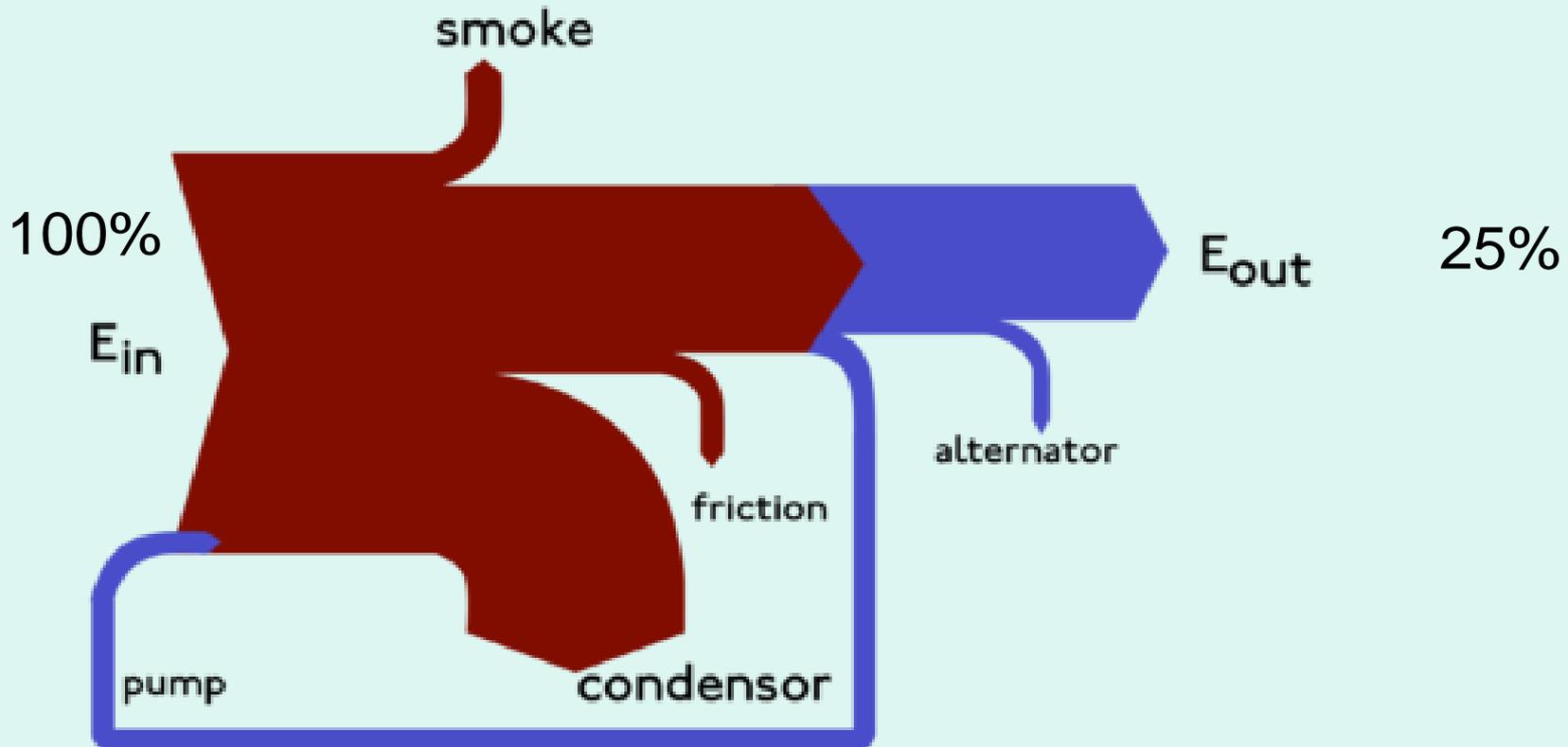
4. Generator

5. Transmission lines

Degraded energy

- Energy which is spread out or disordered. The most degraded form of energy is thermal energy.

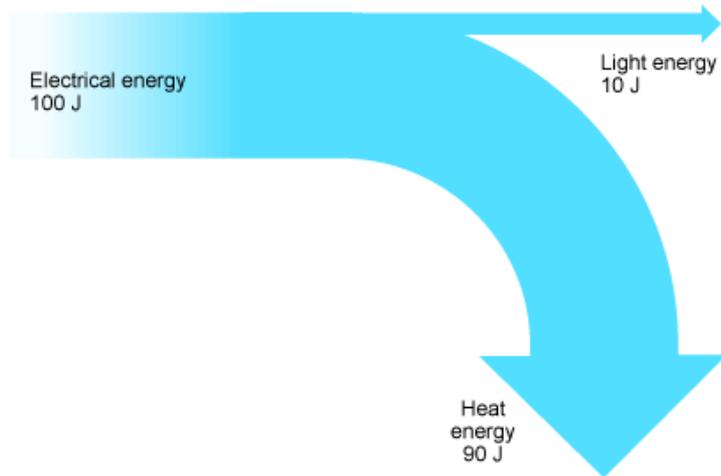
Sankey diagrams



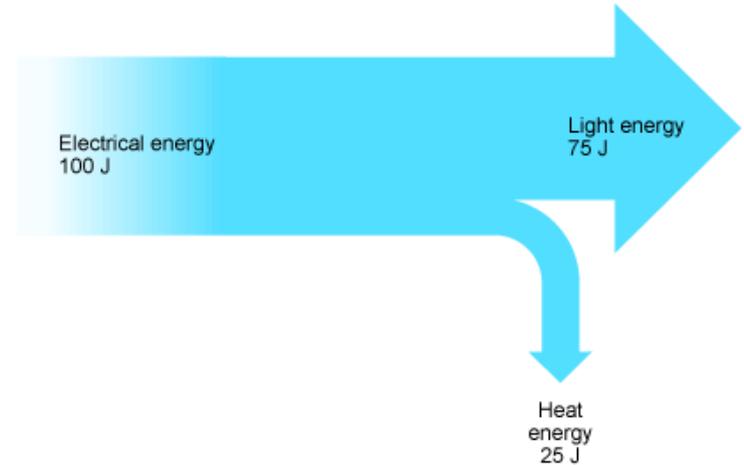
You must be able to construct and analyse Sankey diagrams to show where energy is degraded.

Sankey diagrams for two different light bulbs

Incandescent bulb



Compact fluorescent bulb



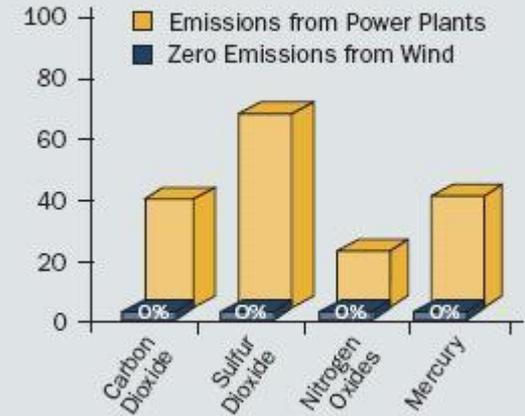
State the overall efficiency of power stations fuelled by different fossil fuels.

- Coal 35 – 42%
- Natural Gas 45 – 52%
- Oil 38 – 45%

Describe the environmental problems associated with the recovery of fossil fuels and their use in power stations.



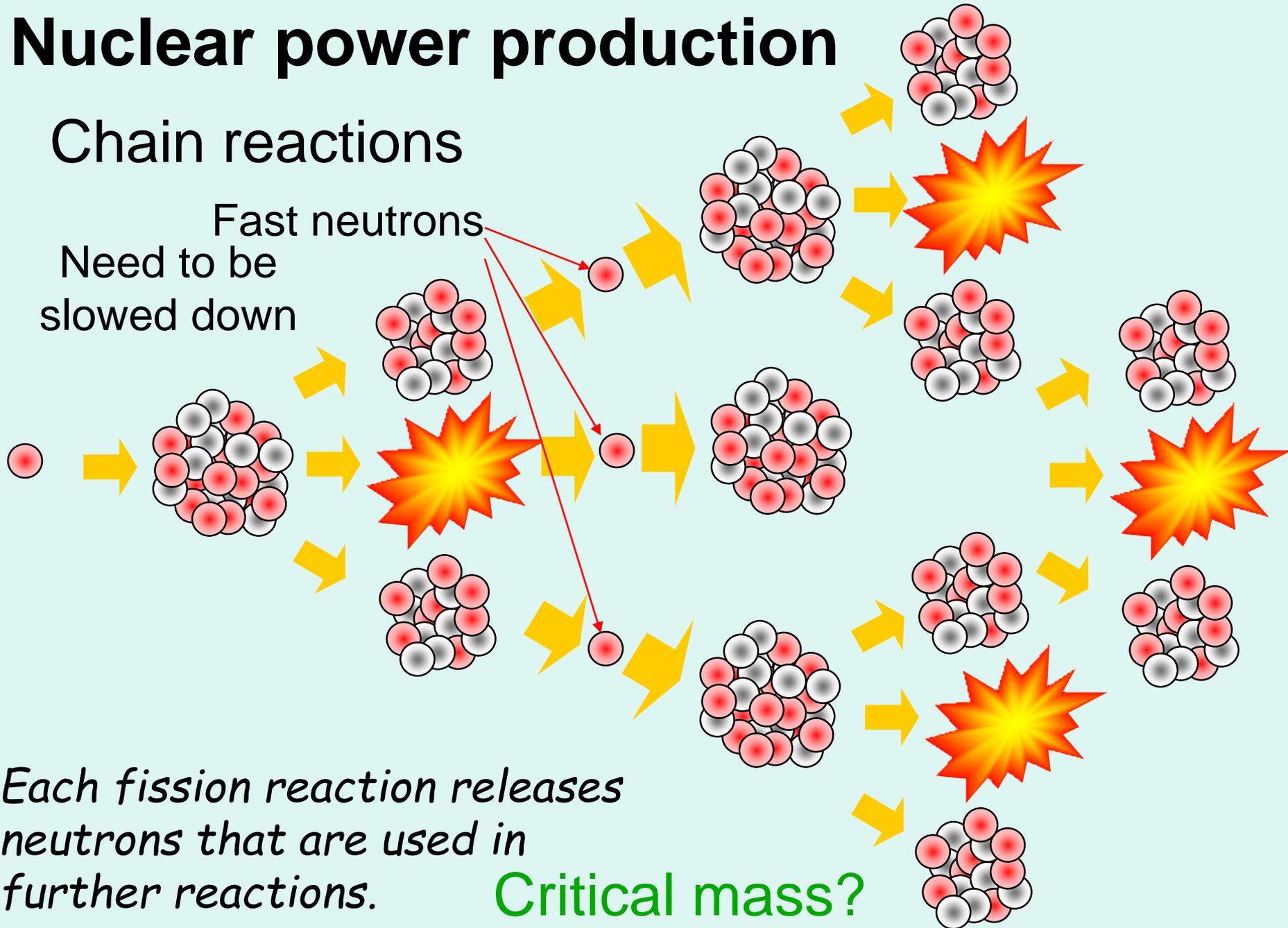
**Leading U.S. Emissions:
Percent from Power Plants**



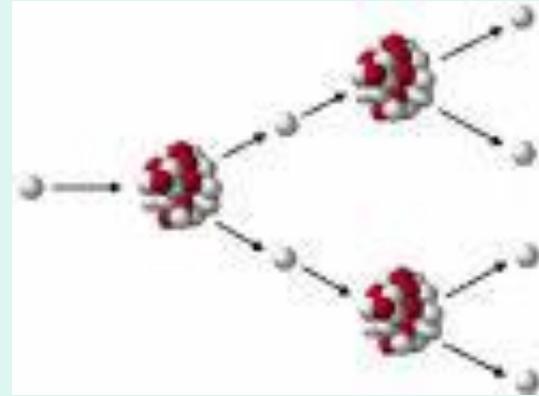
Data Sources: Energy Information Administration, US Environmental Protection Agency. Emissions data is for 2002, mercury data for 1999.

Nuclear power production

Chain reactions



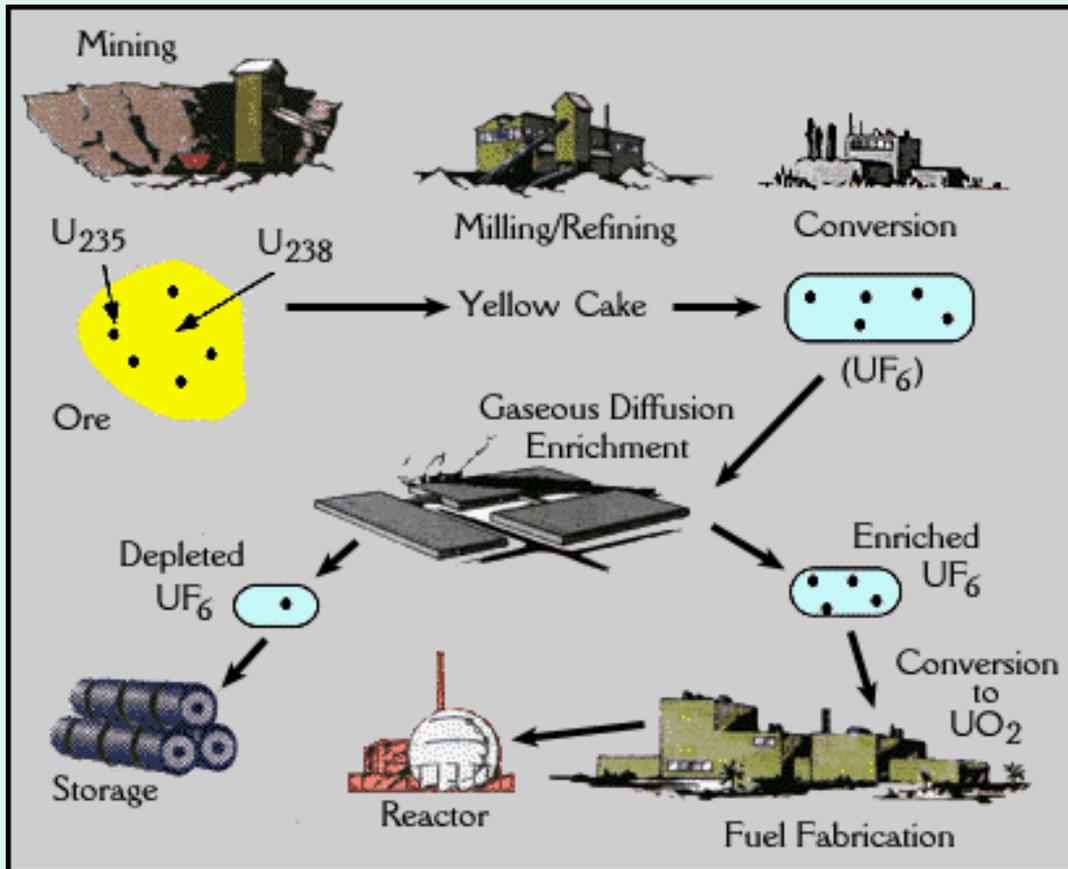
Distinguish between controlled nuclear fission (power production) and uncontrolled nuclear fission (nuclear weapons).



Students should be aware of the moral and ethical issues associated with nuclear weapons.



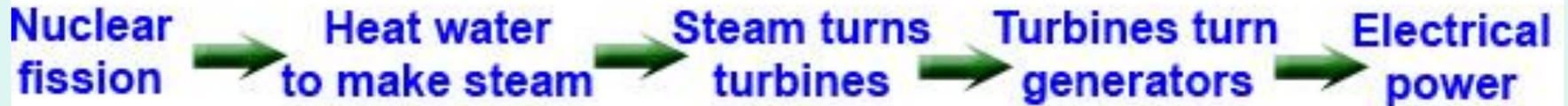
Describe what is meant by fuel enrichment.



Natural U-235 occurs as 0.7% abundance. ($330^{\circ}C$)

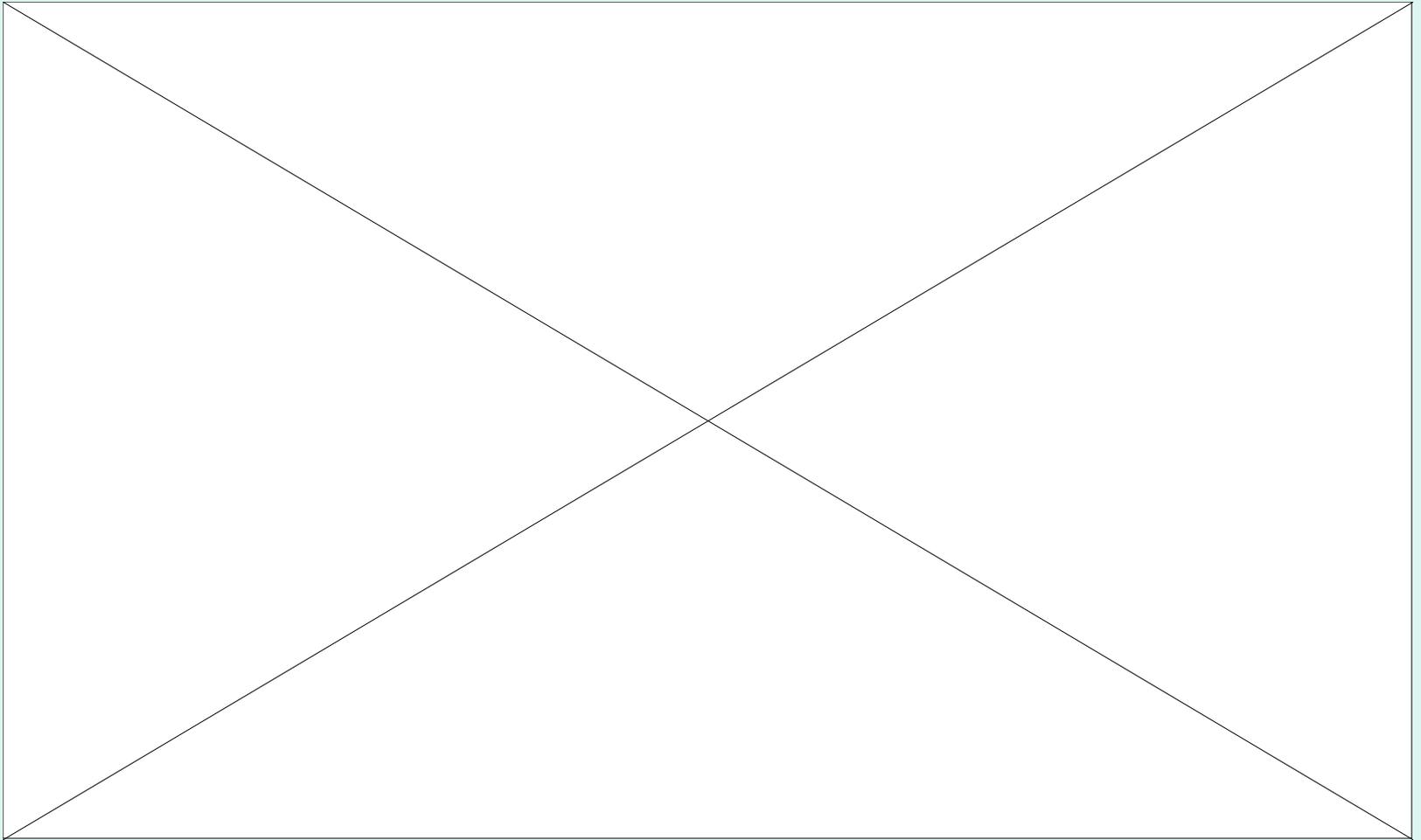
Enriched fuel contains 2.3% U-235, therefore increases the temperature ($600^{\circ}C$) of the core of the reactor, therefore increases the efficiency and power output/Kg

Describe the main energy transformations that take place in a nuclear power station.

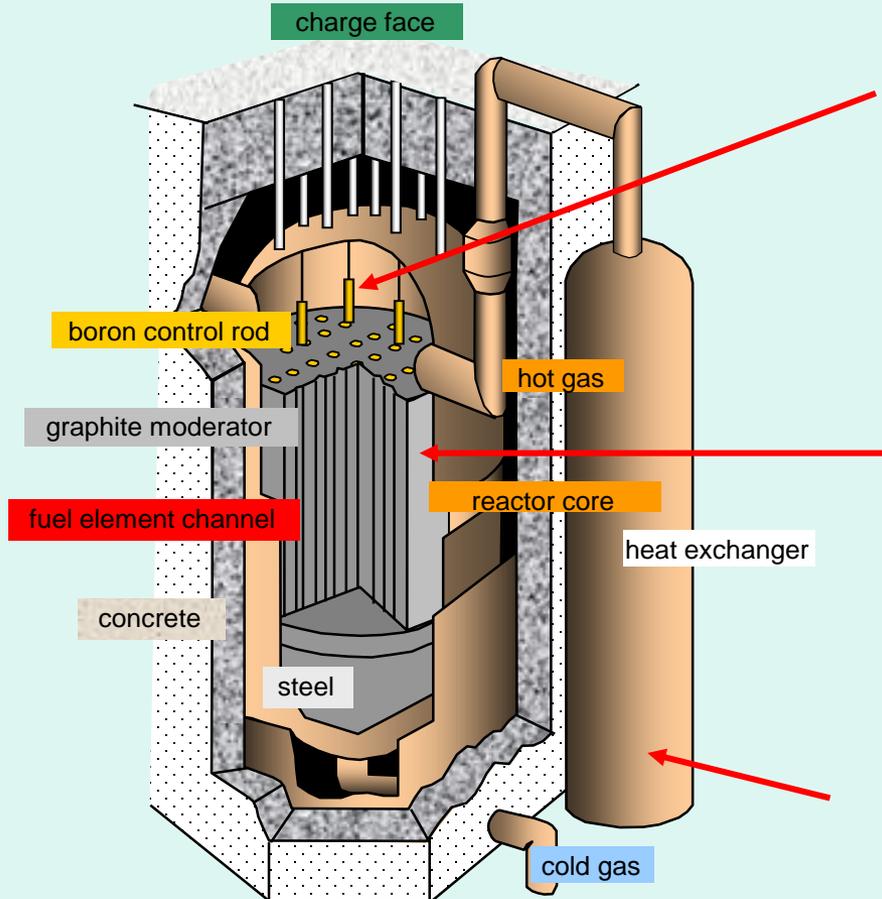


E_K of
fission
fragments

Nuclear power station



Discuss the role of the moderator and the control rods in the production of controlled fission in a thermal fission reactor.



The control rods **absorb** neutrons to **control the power** level

The moderator **slows** the neutrons down to enable them to **allow fissions**

The heat exchanger **isolates** the water from the coolant and lets the hot gas **boil the water**.

What are the energy transformations?

Energy transformations in a reactor

- Fission fragments have E_K
- This heats the fuel rod
- The coolant (gas) takes the heat from the rod
- The hot gas goes to the heat exchanger
- The hot gas turns the water to steam
- The steam drives the turbines
- The turbines drive the generator

Risks of nuclear power

- **Meltdown** – This is when the power goes out of control and the reactor blows up. This may happen if the coolant is “interrupted”, or the control rods are removed.
- The **waste** produced is radioactive, as is hazardous to living things. It is expensive to store. The half life of some products is very long
- Uranium **mining** - Because uranium ore emits radon gas, uranium mining can be more dangerous than other underground mining
- The **plutonium** produced can be used for weapons manufacture



Nuclear fusion

- The plasma needs to be at a temperature of about 10^8K (this takes a lot of energy).
- This cannot come into contact with anything
- Can be contained by a magnetic field.

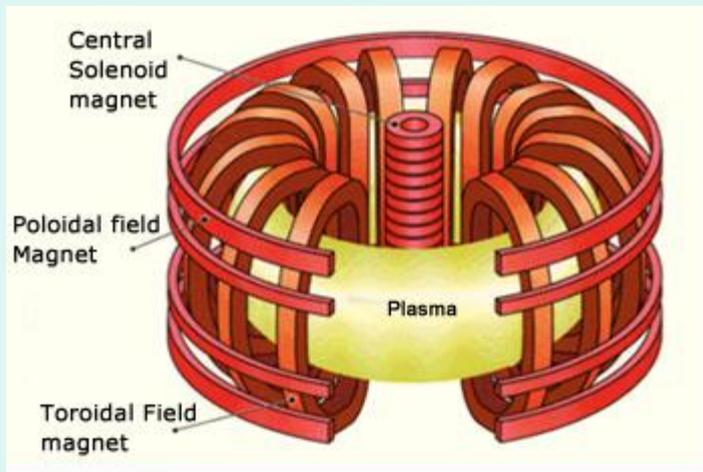


Figure 1 : Tokamak configuration. The toroidal and the poloidal field magnets as well as current in the plasma itself produce the main magnetic field. The central solenoid drives the current in the plasma through transformer action



Solar power

There are 2 types of solar power

1. photovoltaic cell

In a sunny climate, you can get enough power to run a 100W light bulb from just one square metre of solar panel. Good for remote situations e.g. a yacht.



2. Solar water heating

The Sun is used to heat water in glass panels on the roof

This means you don't need to use so much gas or electricity to heat your water at home.



Solar PV cells

- **Advantages**

- Solar energy is renewable and the Sun's heat and light are free
- Solar energy can be used to generate electricity in remote places where other electricity supplies are hard to come by
- It does not produce any carbon dioxide, which contributes to the greenhouse effect
- Energy is usually generated at or near to the location it will be used. This keeps transmission and distribution costs to an absolute minimum

- **Disadvantages**

- PV cells do not work so well when it is cloudy and do not work at night
- They only work in a very sunny country! Solar power works better in hot places, so its use is therefore limited

Solar constant

- The solar constant is the amount of incoming solar electromagnetic radiation per unit area.
- It is measured by satellite to be roughly 1.4 kWm^{-2} .
- This value must be reduced if
- You are not at the Equator
- It is not mid summer
- PV cells are about 10% efficient.

Hyperlink

Hydroelectric power



water storage in lakes

Advantages

- Once the dam is built, the energy is virtually free.
- No waste or pollution produced.
- Much more **reliable** than wind, solar or wave power.
- Water can be stored above the dam **ready to cope with peaks in demand**.
- Hydro-electric power stations can increase to **full power very quickly**, unlike other power stations.
- Electricity can be generated constantly

Disadvantages

- The dams are very **expensive to build**.

However, many dams are also used for flood control or irrigation, so building costs can be shared.

- Building a large dam will flood a very large area upstream, causing **problems for animals** that used to live there.
- Finding a suitable site can be difficult - the impact on residents and the environment may be unacceptable.
- Water quality and quantity downstream can be affected, which can have an impact on plant life.

Tidal water storage

Hyperlink

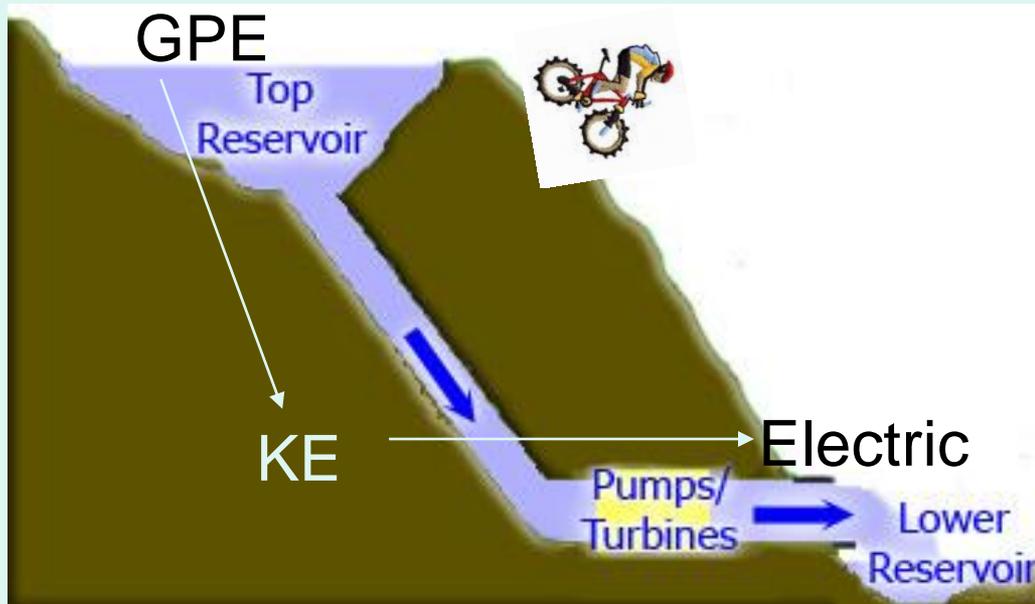


- Tidal Power is renewable
- Doesn't cause pollution, doesn't need fuel
- A tidal barrage is very expensive to build
- Only works when tide is going in or out
- A tidal barrage affects a large area
- There are very few places that you could sensibly build a Tidal barrage
- Underwater turbines may be a better bet than a barrage - they are cheaper and don't have the huge environmental impact

Buy when cheap

Sell when expensive

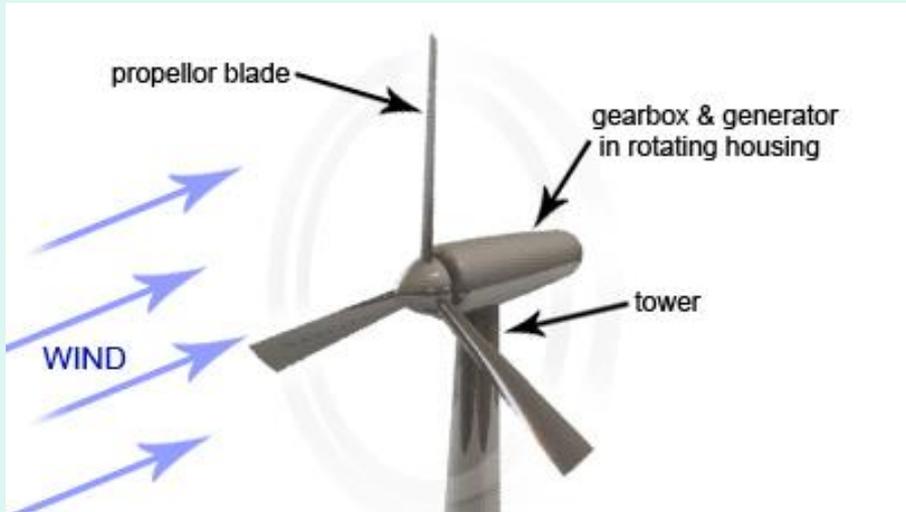
Pump storage



Dinorwig has the fastest "response time" of any pumped storage plant in the world - it can provide 1320 Mega Watts in 12 seconds. That's a lot of cups of tea!

- It's a way of storing energy for when you need it in a hurry.
- The biggest one is at Dinorwig, in Wales
- Expensive to build
- Most power stations take a long time to turn up to full power. Pumped Storage reservoirs mean that we can quickly get more energy for half an hour or so, to keep us going until the other power stations catch up

Wind power



The wind blows the propeller round, which turns a generator to produce electricity



- Wind Power is renewable
- Doesn't cause pollution, doesn't need fuel
- Need a lot of generators to get a sensible amount of power
- Need to put them where winds are reliable

$$\text{Energy} = \frac{1}{2} mv^2$$

$$\text{Mass per sec} = \rho_x \text{ volume} = \rho_x \text{ Area}_x \text{ speed} = \rho \pi r^2 v$$

$$\text{Energy} = \frac{1}{2} \rho \pi r^2 v_x v^2 = \frac{1}{2} \rho \pi r^2 v^3$$

The wind does not stop after passing through the turbine, therefore not all the energy can be harnessed (max = 59%)

Wave power

Advantages

- The energy is free - no fuel needed, no waste produced.
- Not expensive to operate and maintain.
- Can produce a great deal of energy.

Disadvantages

- Depends on the waves - sometimes you'll get loads of energy, sometimes almost nothing.
- Needs a suitable site, where waves are consistently strong.
- Some designs are noisy. But then again, so are waves, so any noise is unlikely to be a problem.
- Must be able to withstand very rough weather

