Fusion energy

- Fusion powers the Sun, and all stars, in which light nuclei fuse together at high temperatures (15 million degrees) releasing a large amount of energy.
- The aim of fusion research is to use fusion to produce power on earth.
- The most promising approach to fusion power is based on the 'tokamak' – a Russian acronym – first developed in the 1960s.
- The fusion process used on earth requires temperatures in excess of 100 million degrees, much higher than in the Sun. The hot hydrogen gas (known as a 'plasma') in the Joint European Torus (JET) at Culham in the UK routinely reaches 200 million degrees Celsius. JET has produced 16MW of fusion power (the world record).
- In a tokamak the plasma is held in a special vacuum chamber with strong magnets isolating it from the walls. Another approach that uses lasers to compress fusion fuel, is less advanced.

Advantages of fusion

- No carbon emissions are generated by fusion.
- The raw fuels are abundant around the globe (no geopolitical issues) and will last for millions of years. They are a type (isotope) of hydrogen – deuterium (found in seawater) – and lithium (a light metal which is found in the Earth's crust and in seawater). The lithium in the fusion reactor wall produces tritium (another isotope of hydrogen). In the plasma the deuterium and tritium fuse to produce energy.
- Fusion is a very efficient form of energy production. 1 kg of deuterium and tritium would supply the same amount of energy as 10 million kg of coal. The lithium in one laptop battery plus the deuterium from half a bathtub of water would provide the UK's per capita electricity production for 30 years.
- Fusion is environmentally responsible and it has intrinsic safety features. There is no possibility of a run-away reaction or explosion, no greenhouse gas emissions, and although radioactive materials will be generated in the walls of a fusion power plant they would decay with half-lives of about 10 years and the whole plant could be re-cycled within 100 years. In principle this gives fusion significant advantages over nuclear fission (the splitting of heavy nuclei) on which conventional nuclear power stations are based.
- Tritium is a hazardous radioactive substance (with a half life ~12 years) but the amount that is present in the reacting plasma at any time is tiny (only a fraction of a gram). Even if 1 kg were released (and nobody has been able to imagine how this could happen) it would probably not be necessary to evacuate anyone outside the site.
- The estimated cost of electricity generated by fusion is similar to the cost of electricity produced in other environmentally responsible ways.

The road to commercial fusion power

- Fusion has complex scientific and engineering challenges (such as confining the plasma and finding suitable structural materials for tokamaks) which have made progress towards commercial power slower than expected. However, many of these have been overcome and the next major fusion experiment – ITER – will observe fusion power on a commercial scale (500 megawatts) for the first time. ITER is being built in Cadarache, France and is a partnership between Europe, Japan, China, Russia, the United States, India and South Korea. It will begin operating in ten years' time.
- ITER will be followed by a demonstration powerplant – 'DEMO' – which is expected to be ready in 25-30 years. If successful, the first generation of commercial fusion power stations will then be built.
- The timescale to fusion power could be accelerated with increased funding. Overall research spend on fusion is tiny – less than 0.1% of the total energy market worldwide. This is astonishingly small compared to what a large hi-tech or automotive firm would spend on research (e.g Toshiba, Ford). ITER's expected lifetime cost is less than the amount being spent on the London Olympics.