When it's time to be HiPER aware

Fusion is not a new concept. For over 40 years, physicists have seen it as the Holy Grail of energy production. Despite the political obstacles currently facing nuclear power, there are other schemes that claim to hold more promise for fusion projects - like HiPER.

HIPER IS short for the £500 million 'High Power Laser Energy Research' experimental reactor whose aim will be to create laser-based nuclear fusion by harnessing the same process that drives the sun.

The project says it can offer an increasingly major contribution to solving long-term energy needs, as part of a mixed-energy economy, as it moves towards a carbon-neutral alternative to fossil fuels, which also produces very little radioactive waste.

Nuclear fusion, which uses seawater as its principal source of fuel, is the process by which atomic particles link up and form a heavier nucleus, followed by the release of energy.

Professor Mike Dunne of the Harwell-based Rutherford Appleton laboratory and HiPER project leader explains how the system will function: "HiPER would work by firing tiny pellets of hydrogen across a steel vacuum chamber. At a critical point along its trajectory, each pellet would be hit by laser light. The beams would be so powerful the pellet would be simultaneously crushed and heated, achieving temperatures of around 100,000,000C - about 10 times hotter than the sun.

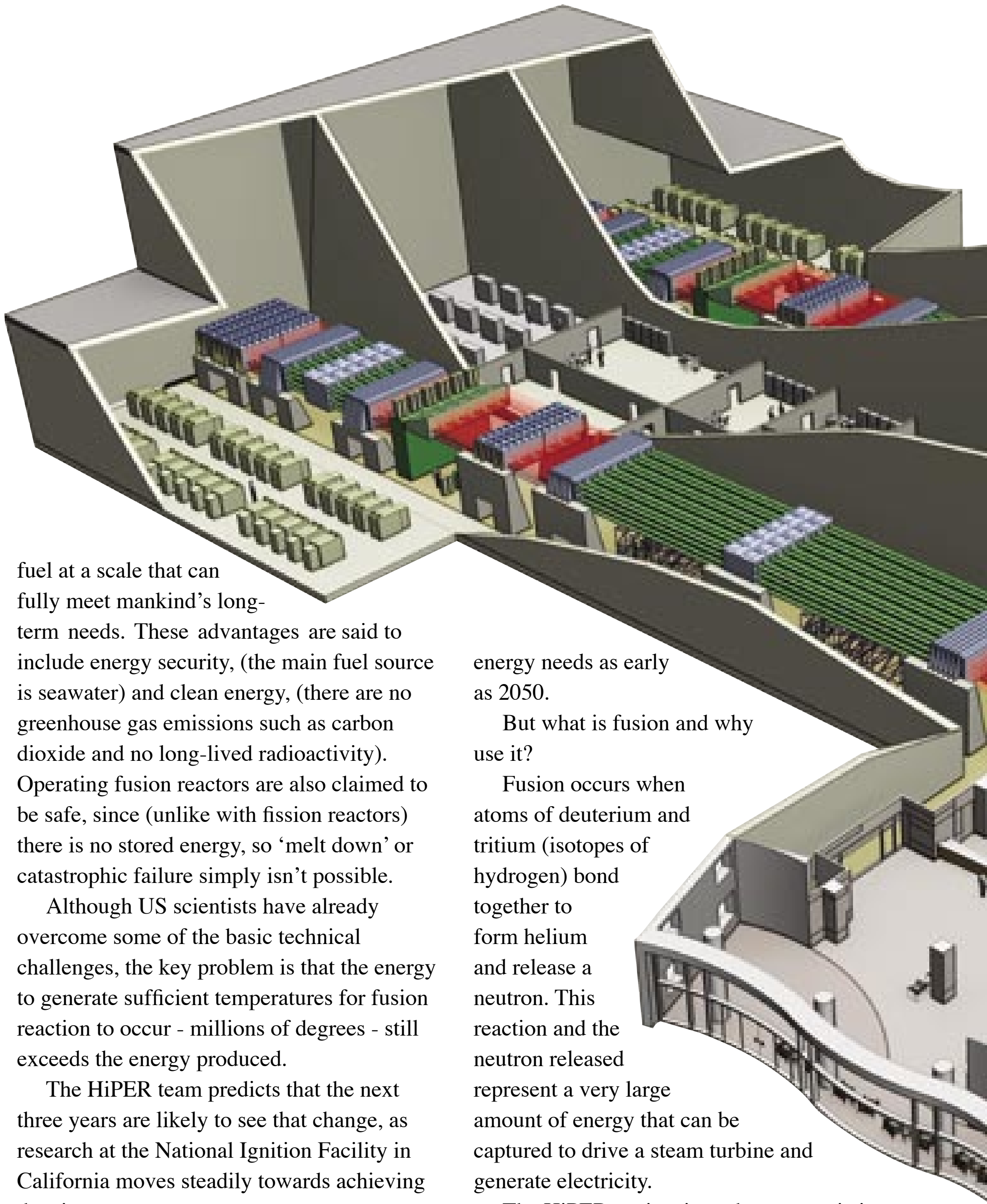
"At such temperatures the atoms that make up all matter are ripped apart. The outer electrons are stripped away and the hydrogen nuclei fly around at such fantastic speeds that when they collide they fuse. As they fuse, some of their mass is lost and converted into large amounts of energy in the form of heat, light and radiation. It is this energy that we hope to capture and turn into electricity."

Laser-based nuclear fusion, according to the HiPER project, is said to offer plentiful fuel at a scale that can fully meet mankind's long-term needs. These advantages are said to include energy security, (the main fuel source is seawater) and clean energy, (there are no greenhouse gas emissions such as carbon dioxide and no long-lived radioactivity). Operating fusion reactors are also claimed to be safe, since (unlike with fission reactors) there is no stored energy, so 'melt down' or catastrophic failure simply isn't possible.

Although US scientists have already overcome some of the basic technical challenges, the key problem is that the energy to generate sufficient temperatures for fusion reaction to occur - millions of degrees - still exceeds the energy produced.

The HiPER team predicts that the next three years are likely to see that change, as research at the National Ignition Facility in California moves steadily towards achieving the aim.

If the project does succeed, fusion-powered reactors could start to play a significant role in supplying the world's energy needs as early as 2050.



But what is fusion and why use it?

Fusion occurs when atoms of deuterium and tritium (isotopes of hydrogen) bond together to form helium and release a neutron. This reaction and the neutron released represent a very large amount of energy that can be captured to drive a steam turbine and generate electricity.

The HiPER project intends to use existing laser technology "in a unique configuration", with a 200kJ long pulse laser working with a 70kJ short pulse laser.

These are the estimated powers of the system required to compress the fusion fuel to a high enough density to ignite it, inducing a propagating burn wave to yield high gain.

Scientists anticipate that American colleagues will achieve this for the first time as early as 2010 to 2012.

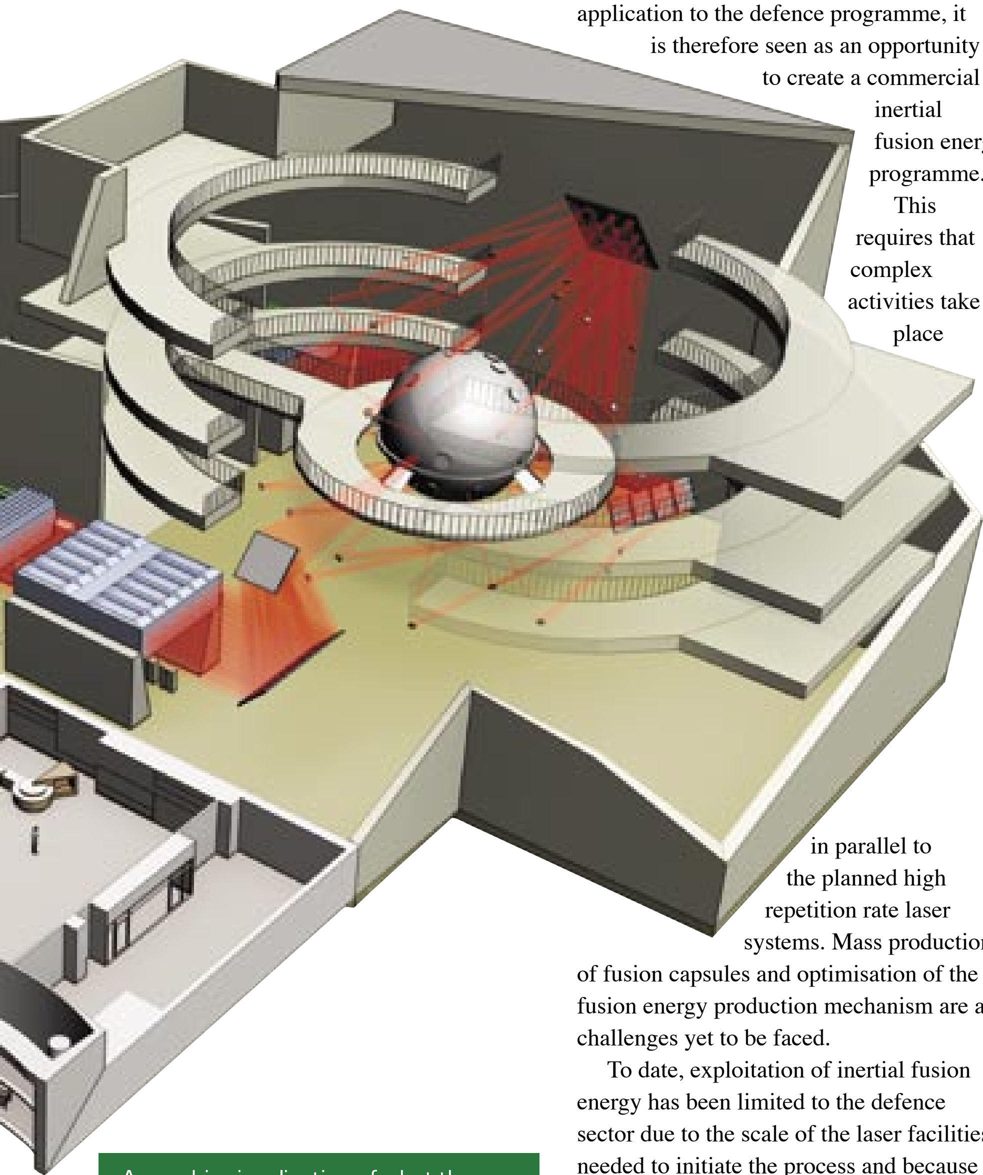
But before everyone gets too excited, the HiPER team emphasises that fusion is not a short term fix, but one that will take concentrated research and development effort across a range of options to realise its potential.

In the 1970s it was proved possible to use lasers to implode a capsule of fusion fuel to release significant energy - a process called 'inertial fusion'. Since then laser development around the world has gone far towards developing lasers capable of driving such fuel capsules to the point where this fusion energy release can be harnessed.

According to HiPER: "With the latest generation of lasers at National Ignition Facility (NIF) in California and Laser Mégajoule (LMJ) in France, we are on the threshold of achieving 'ignition". This is the real challenge... to demonstrate a self-sustaining fusion reaction with a net production of energy, a reaction which releases more fusion energy from the capsule than is needed to drive the laser system".

It is claimed that the advent of 'fast ignition' - the approach used by HiPER - will completely change the energy landscape by removing dependence on defence programmes. Fast ignition capsules are planned to require far smaller laser systems and only use optical irradiation to trigger fusion. Since this is claimed to have no direct application to the defence programme, it is therefore seen as an opportunity to create a commercial inertial fusion energy programme. This requires that complex activities take place in parallel to the planned high repetition rate laser systems. Mass production of fusion capsules and optimisation of the fusion energy production mechanism are all challenges yet to be faced.

To date, exploitation of inertial fusion energy has been limited to the defence sector due to the scale of the laser facilities needed to initiate the process and because of the classified nature of the x-ray driven implosion.



A graphic visualisation of what the HiPER laser building might look like.

Key point:
1 Fusion-powered reactors could start to play a significant role in supplying the world's energy needs as early as 2050.

Incidentally, HiPER is not to be confused with ITER; a much larger project under construction in France that will attempt fusion by a completely different approach, using hugely powerful magnetic fields to heat and contain the fusion process. Professor Dunne hopes both the ITER and HiPER routes to fusion will come to fruition. "The world needs both systems to succeed in tackling this major energy issue for our future," he says.

The laser Professor Dunne proposes to build is "truly immense: roughly ten thousand times the power in the entire UK national grid", but needing to deliver that huge amount of power for only a tiny period of time; just a few trillionths of a second. According to the project, the beauty of the system is that the energy is only required for an incredibly short time.

Although it is highly likely that the HiPER prototype fusion reactor will be built in the UK, the project is truly international and incorporates researchers from France, Poland, Portugal, Russia and Spain.

However huge challenges face the team. These include the daunting task of building a laser of immense power that must be capable of firing repeatedly for incredibly short periods of time. Nevertheless, the scientists believe they can do it.

With the rising threat of climate change, it seems that Professor Dunne's timing could not be better.

In July last year the European Commission gave initial approval for HiPER to go ahead, assigning up to three million Euros (over £2m) in funding for the first part of the three-year planning phase.

Starting in April 2008, the aim of the HiPER team will be to define the technologies that will be used to build an experimental prototype laser fusion reactor. This will be followed by a two-year definition phase from 2011 to 2013.

Professor Dunne is undaunted by the challenges ahead. "We are just a couple of years away from seeing fusion in the lab. This is not going to solve the immediate problem of greenhouse gases, but rather it is a solution that is being designed to provide an abundant clean source of power to meet the long term demand."