News Energy & environment Nuclear

ITER nuclear fusion reactor design receives approval

By **Stephen Harris** 25th April 2013 2:20 pm

Engineers planning the world's largest nuclear fusion reactor have completed designs for the system's most technically challenging component, known as the 'blanket'.

The team at ITER based in southern France are hoping to build the first experimental nuclear fusion reactor to generate more energy than it consumes, with the aim of creating a power source that doesn't produce carbon dioxide or large amounts of long-term radioactive waste.

The proposed blanket system that will line the inside of ITER's doughnut-shaped 500MW tokamak reactor chamber overcomes the major challenge of how to absorb some of the 150 million °C heat that will be generated by the fusion reaction while containing the radiation produced.

ITER's engineers say the blanket is the last major component to be designed and completion will allow the project to move to the main manufacturing stage, with procurement due to start later this year and eventual assembly of the blanket scheduled to begin in May 2021.

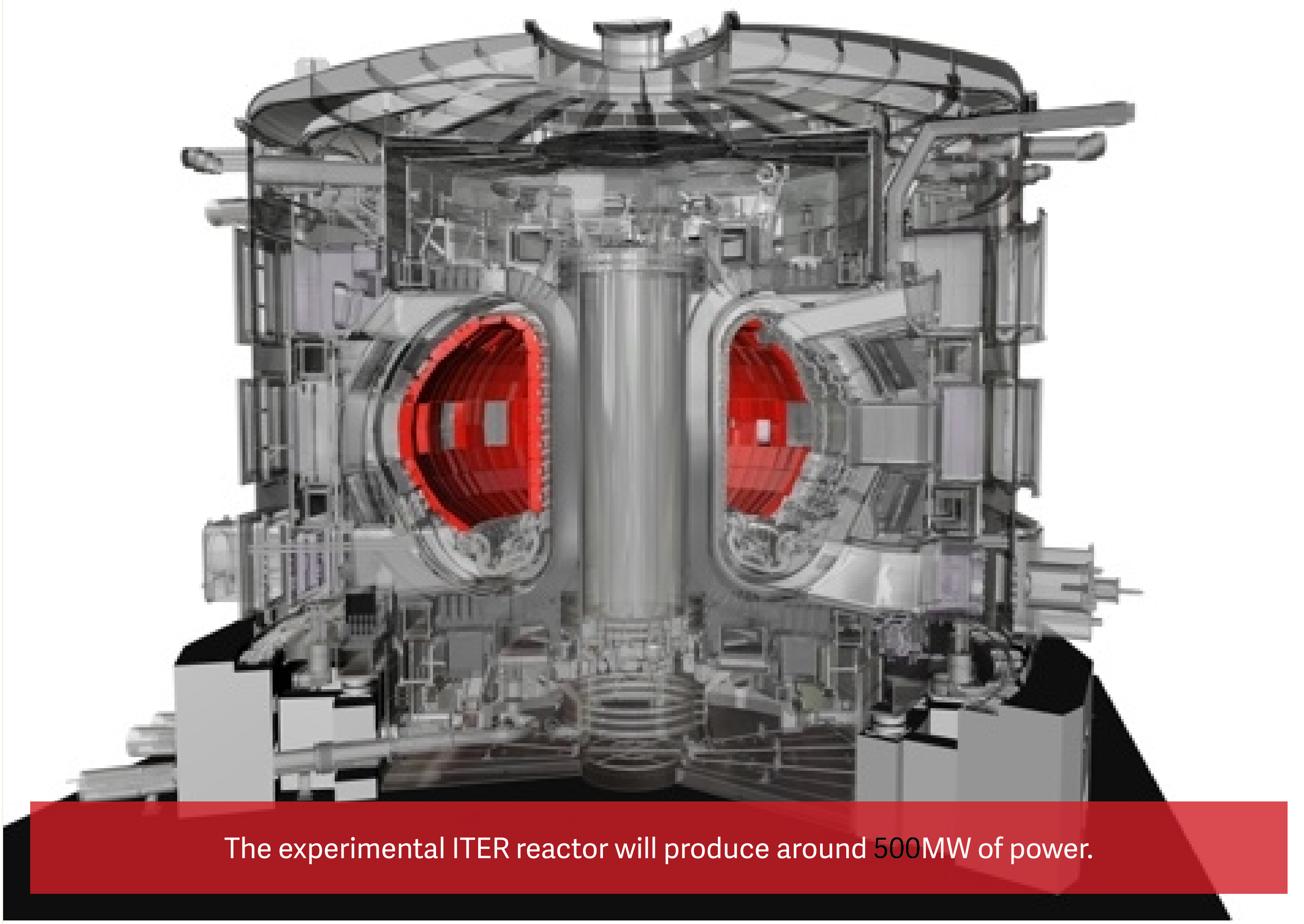
the whole ITER machine.'

The reactor will mirror the process that generates energy in the Sun: two isotopes of hydrogen are heated to extreme temperatures so they become ions (plasma) and then collided and fused together, releasing a fast-travelling neutron that transfers energy as heat.

The blanket is what will capture this energy. It will consist of 440 four-tonne modules covering a total surface of $600m^2$, each comprising a beryllium 'first wall' containing a water-cooling system to contain the plasma and absorb the heat, and a water and steel shield block to absorb the neutrons themselves.

Each first wall panel will be made from a number of 'fingers' attached to a central backbone through which the pressurised cooling water will flow, passing over an array of cooling fins and reaching temperatures of up to 150°C.

'[This means] if during the manufacturing something goes wrong, at worst we reject the finger and not the whole part, which would be quite valuable,' said Merola.



The experimental ITER reactor will produce around 500MW of power.

Test ideas include breeding tritium from lithium held in ceramic material or from a liquid lithium lead compound. Future commercial-scale reactors would likely include tritium breeding on each of the blanket's modules.

Previous designs for the ITER blanket featured two dedicated components for limiting the plasma but the engineers decided this would not provide enough flexibility and so redesigned the system so the entire blanket would act as a physical boundary to the plasma.

This meant each module had to be shaped to produce a curved surface so if there were any manufacturing misalignment the edges would not protrude with a sharp leading edge into the plasma and risk damage.

This issue also led the engineers to separate the shield block from the first wall so the more vulnerable, plasma-facing element could be replaced if needed without removing the entire module. Each panel is expected to be replaced at least once in ITER's lifetime.

The first wall panels will need to absorb both the radiative heat on the surface at an intensity of up to $5MW/m^2$ – around 5,000 times more than that felt on a summer's day outside in the south of France – and the volumetric heat transferred by the neutrons, which carry around 80 per cent of the energy produced by the fusion reaction.

The blanket also needs to cope with electromagnetic loads, forces exerted by magnetic fields interacting with the currents induced when the reactor shuts down abruptly.

Once the first wall has captured the neutrons' heat, hydrogen and iron atoms contained, respectively, in the shield block's optimal combination of water and steel will absorb the neutrons themselves.

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  Peter Higgins 26th April 2013 at 12:36 pm

  I think that figure of 500 times a French summer's day should be 5,000 times.

- terry 26th April 2013 at 4:54 pm

  It all seems a bit Victorian and archaic to me
  Using all this technology to make a steam engine
  We should be developing a real break through in propulsion and generation with systems that do not involve combustion

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- terry 26th April 2013 at 7:17 pm

  this fusion project is about boiling water and making steam to drive turbines and will be unsuitable for domestic use in that the consumer will be reliant on a centralised electricity supply

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- terry 26th April 2013 at 7:28 pm

  following on from previous
  to avoid the steam raising cycle it should be possible to align the electrons in the plasma and then extract them into a electric cables
  so producing electricty directly

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- Alex 26th April 2013 at 7:43 pm

  I'm sure the Physics will work out – the Physicists say so. But from an engineering persepctice, this is a lot of cost and complexity to produce 500MW – I assume of thermal energy – not electricity?

  I can't see this being cheaper than Uranium based fission, and it's not really much cleaner than Thorium based fission.

- Andy H 26th April 2013 at 8:24 pm

  Fusion does not involve combustion, but terry is right in saying that steam generation is a wrong move.

  There are many fusion concepts that can generate electricity directly from the reaction. They are smaller and theoretically more efficient.

  Tokamak has proven with JET that the concept doesn't work, I'm not saying the JET research was fruitless, but the reactors get bigger and bigger and we still don't have a net fusion gain, let alone net energy production.

  NIF is for weapons research, contrary to the political spin.

  With Tokamak, we're 50 years away from a working prototype.

  The funding needs to be spread around, with other concepts seeing greater investment.

  Fusion has the capability to fundamentally change the Energy supply.

  But we'll never succeed throwing all our eggs in one basket.

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- Alicia 27th April 2013 at 3:01 pm

  I'm curious about the use of fresh water. Is there anyway to reuse water in the cooling process?

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- Martin 27th April 2013 at 10:49 pm

  What are the long term contamination issues from the radiation produced?

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Ron Shaw 28th April 2013 at 8:10 pm

Kind of funny that I first heard about ITER by reading Alex Jones' Infowars.com site…and I think of myself as fairly well informed about science and technology…obviously not! Good to see several nations working together on this. I personally believe fusion is the ultimate answer to our energy needs. (duh…)

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- Andy H 3rd May 2013 at 7:01 pm

  @Martin, the tokamak reactors will be just as dangerous as expired fission reactors. They are bombarded with high energy neutrons for 20 years.

  There is much less radioactive waste, but the reactor building will take years to clean up, just as with fission.

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- Anonymous 7th May 2013 at 2:55 pm

  The half life of radioactive waste products in fission reactors is significantly larger than that of fusion reactors (thousands of years compared to approx. 50-100 years).

  Also, once the reactor is turned off or no fusion reaction occurs then neutron radiation will almost instantaneously end.

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- John Downes 19th May 2013 at 11:54 am

  Having visited JET Laboratories in Abingdon and invited to work on the ITER project over in Garching back in the 80s I came to the conclusion then that this 'infinite' energy source is a holy grail we're never going to find. Thirty years on and billion$ spent, I cannot believe we are any further forward.

- Vince 20th May 2013 at 9:12 pm

  A lot of people missing the point here. This is a research project to scale up fusion to productivity scale and prove the technology. The steam raising plant is a tried, tested and trusted way of removing the generated heat and usefully converting it into electricity – one step at a time folks!!

  Reply Link Quote

- Anonymous 22nd May 2013 at 3:39 am

  Materials irradiated by neutrons aren't generally 'radioactive' the danger of fission waste is leftover U, Cs, and Xe from the fission process which undergo radioactive decay. The elements used for fission are not generally unstable and materials bombarded by neutrons, while affected, do not become radioactive. Instead they are generally embrittled

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- Anonymous 23rd May 2013 at 7:03 pm

  Andy H: fusion creates no radioactive waste what so ever and it is relatively safe unless the electricity powering the electromagnets goes out causing the plasma to melt through the walls of the donut and melting the building killing thousands of people in the process

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  Email

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