{* **SCIENCE** *}

Nuclear fusion: power to the people?

Or just political hot air?

By Charles Arthur 6 Jul 2005 at 11:40 SHARE ▼

Analysis It's G8 week, and climate change is high on the agenda. And now that even George Bush has acknowledged that climate change is (a) happening and (b) is at least partly due to humans but insisted it (c) should be tackled through technology, why not focus again on a technology that's (1) happening and (2) partly controlled by humans?

That is, nuclear fusion. Unlike fission, already used to produce most of France's electricity, fusion isn't commercial yet. Even its most positive advocates reckon it'll be more than 25 years before a fusion reactor could contribute usefully to the power grid ("useful" being defined as a steady output of 1 gigawatt; the UK has about 42 GW of installed electric plant).

But it does have one very important advocate, and another who is coming along for the ride, and they're both G8 leaders. The advocate: Tony Blair. The one along for the ride: George Bush. Plus it also involves two other G8 nations, France and Japan, directly, as they'll get tons of money from contracts to build the next stage in the long, long road to commercial fusion.

Last week France was chosen as the site for the International Thermonuclear Experimental Reactor (Iter) project, beating Japan's bid. If it works, ITER will take in 50 megawatts of power and put out between 500 and 1,000 MW. That's right - it could power itself.

Here's how. Fusion is what powers the stars. They burn by slamming two hydrogen nuclei (protons) together, to produce a helium nucleus (two protons) and some extra particles. (See the whole system here.)

On Earth, we cheat a little by fusing a nucleus of deuterium (hydrogen with a neutron aboard) with one of tritium (hydrogen with two neutrons), to produce a helium nucleus plus lots of energy in the form of a "fast" neutron. Simple on paper; fiendishly hard in practice. You have to heat the material to about 100 million Centigrade until it becomes "plasma", confine it using magnetic fields, and compress it so fiercely that you overcome the natural tendency of nuclei to repel each other as fiercely as Steve Ballmer encountering an iPod.

Deuterium is plentiful. There's enough in a bath to generate all the energy you'd need in your lifetime. Tritium is trickier, produced either from deuterium fusion, or other decay products. It's used in nuclear weapons, exit signs that work without power, and some illuminated watches.

If you can control the fusion reaction and keep it going, you produce huge amounts of "fast" neutrons which heat up the reactor vessel. That heat can produce steam which can turn turbines to generate electricity. Nuclear waste? Well, the reactor walls might be a little radioactive after you stop; but in 10 years' time you could reuse the parts in another reactor. Tritium is poisonous, but wouldn't get out. And the reaction can't run away like fission can; if the magnetic "bottle" fails, the reaction stops.

Big science

The politics similarly involves bashing people's heads together at sufficient pressure to produce a solid project and a fast-moving schedule to make it happen. For years fusion was on the slow track. That's because it's big science, and thus big politics are involved to make it happen. Although the Joint European Torus project in Abingdon, Oxfordshire, managed to generate 80 per cent of the power put into it - falling just short of being self-sustaining - it demonstrated what could be done. In 1985 Ronald Reagan signed an agreement with Mikhail Gorbachev to work towards ITER, with the aim of producing a prototype commercial reactor this century.

But in 1998 Bill Clinton's administration withdrew from ITER, citing costs, and the US began going it alone with its own FIRE fusion project.

And ITER will cost. The budget is estimated at $12bn - shared between Europe, the US, China, Korea, Japan and Russia - and a lifespan of about 30 years. Then again, that's only £6.6bn at present exchange rates. That would buy you a British national ID card scheme; in fact Britain's share is much less, and it could even generate £100m of revenues for British businesses annually.

But what's remarkable is how fusion has abruptly moved up the agenda. It's not for scientific reasons though, but politics. And it comes down to one person: Tony Blair.

He's come under pressure at home from Professor Sir David King, the government's chief scientific adviser, to do something on climate change. In 2001, he headed a European panel looking for a fast-track to fusion, and concluded (PDF) it was feasible. The problem is that renewables like wind, waves and solar can't cover the energy shortfall once the UK's nuclear power stations go offline around 2020; presently fission produces 25 per cent of the UK's electricity.

Building more nuclear fission stations looks the easy option, but Margaret Beckett, at the Department of Environment, Food and Rural Affairs, hates them and talks them down as fiercely as King talks them up. She sees them as vote-losers because nuclear waste disposal gives environmental groups a stick to beat Government with. By contrast, the only criticism (though it's a zinger) environmental groups like Greenpeace have of fusion is that it's a lot of money that could be spent subsidising or building renewables now.

That makes fusion the politically acceptable solution. Professor King likes it, Beckett doesn't dislike it, and the greens can't hang you for it. So two years ago at a Camp David summit Blair himself persuaded Bush to rejoin ITER and stop funding FIRE. (In such ways is political goodwill generated by supporting the US over Iraq recouped.)

So, note a key passage in Dubya's interview with ITN about how to get around climate change: "If people want to come together and share technologies and develop technologies and jointly spend - and spend money on research and development, just like the United States is, to help us diversify away from fossil fuels, [I am] more than willing to discuss it. I know we need more nuclear power in order - nuclear power, after all, is not dependent on fossil fuels and emits no greenhouse gases."

Note he doesn't specify what sort of nuclear power, and how he does emphasise coming together on R&D; though the US did oppose the siting of ITER in France, preferring the rival site, Japan, which would thus have got the guaranteed construction jobs and contracts. Why? Well, which country supported the US on its Iraq adventure, and which didn't? As we said - politics, not science, rules here.

But once the politicians have gone away, ITER's scientists can get on with the task. Which isn't trivial. But right now they're as happy as dogs with two tails, especially compared to a few years ago when it seemed the entire fusion project would run into the dirt. The arrival of climate change as a political hot potato has given their cause new fuel, and they're burning it as quickly as possible.

Big question

The big question is, can it work? Can "hot" fusion ever be commercial? We'll deal with that in just a moment.

But first, some think that commercial fusion is much closer than grand projects like ITER make it seem. For them, cold fusion never went away, just went underground, much like its "hot" sibling. The publication in April of a letter in the science journal Nature by a team at UCLA who apparently achieved small-scale fusion in a laboratory has had some people agog.

The trouble is that it's not going to generate cheap electricity. It seems to work, but doesn't scale: you can't get more energy out than you put in. So this crystal-based technique could produce fast neutrons, for radiotherapy or X-ray machines; but not a power generator. "It's very interesting, but it's not a power source," says Chris Carpenter, spokesman at JET. "These small-scale things aren't viable because they don't scale up."

For that, you need something like ITER - because hot fusion does scale, gloriously. ITER will only be twice the size of JET, yet should generate more than 75 times as much power.

And the potential? "You have an energy market that's worth about $3 trillion worldwide annually, and electricity is one-third of that," says Carpenter. "If we invest big now in fusion, then it could pay off. OK, perhaps it won't work; in that case we've found out sooner, and we can try something else to generate the power we need. We aren't saying fusion is the only option. But it's probably the only non-polluting, large-scale option."

But what's changed since JET was built to make it any more likely that fusion won't remain forever 30 years in the future? The materials, says Carpenter, and the computers. From helium-cooled superconducting magnets to tungsten chamber walls to supercomputers that can calculate how the plasma will behave far more accurately and quickly than ever before, the pieces are all there, waiting for the politicians to sign off the cheques and shake hands.

Sorry, by the way, if you thought that solving the world's energy problems was about something as trivial as *science*. As might be clear, it's really all politics.

And finally: fusion scientists have managed to get all this cash without enlisting Sir Bob Geldof or getting Pink Floyd to reform. Imagine if they had: we'd probably all have fusion-powered cars by now. ®

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