SCIENCE AND TECHNOLOGY

The fusion thing

THE ECONOMIST FEBRUARY 8TH 1992

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Yet, for the first time in fusion programmes, such science will have to share the limelight with the reactor's engineering—an indication (unwelcome to many fusion scientists) of the fact that fusion is nearing the day when it must appeal not only as an idea, but also as an investment for hard-nosed utilities companies.

That said, fusion scientists are already emphasising ITER's "scientific" nature—a dangerous sign that they are ready to postpone an economic assessment of their art.

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WITHIN the next eight weeks fusion scientists will ask for a down-payment of $1 billion on their newest toy. The scientists, who have never been short of vision, like to think of ITER (the International Thermonuclear Experimental Reactor) as the penultimate step in an epic 80-year journey to harness for electricity generation the process that powers stars. Earth-bound taxpayers, who will pay fusion's bill, should be more sober. As ITER drags fusion towards the drab familiarity of everyday use, fusioneers must be made to think about the economic case for their brainchild.

As a stirring endeavour, ITER cannot fail to inspire even the most ledger-loving accountant. The hydrogen in ITER's dough-nut-shaped core will be 10-20 times hotter than that in the centre of the sun—enough to smash its atomic nuclei together so that they fuse and release energy. The machine will take six years to plan. It will be eight years and $5 billion in the making and weigh several thousand tonnes.

It is also history's first truly global slice of big science. In 1987, long before world leaders thought of politicking in harmony, Soviet, American, Japanese and European scientists began to pool their fusion efforts. European sources say Russia has now intimated that it will take on the Soviet mantle. An agreement to design the reactor looks set to be ratified in April at the latest, with design centres in San Diego in California, Garching in Germany and Naka in Japan. The go-ahead to build ITER (assuming it is not scuppered by wrangling over where the machine should be located) will not come until 1996 or beyond.

The vision behind fusion research is no less grand than the plans to realise it. The raw fuels, deuterium (a heavy type of hydrogen) and lithium (which is transformed into a second type of hydrogen, called tritium, before being injected into the reactor), can be extracted from brine—one gallon of sea water contains the energy of 300 gallons of petrol. Because there are only a few grammes of fuel in the reactor at any time, there is no danger that a fusion reactor can melt down (unlike its fissile cousin). Moreover, fusion produces energy without at the same time producing carbon dioxide, the main greenhouse gas. As fossil fuels dwindle over the next few centuries, fusioneers dream that their clean process will fill the breach.

The dozen or so reactors in the world today (machines such as Europe's JET, America's TFTR and Japan's JT-60) are relatively small affairs. For almost the whole of their lifetimes these reactors have mimicked a sustained deuterium-tritium fusion reaction with a tamer deuterium-only version in pulses that last about five seconds apiece. As well as benefiting from the knowledge accumulated on today's machines, ITER will burn better than they ever did for two reasons: it will be ten times their volume and will use a deuterium-tritium mixture. According to Paul Rutherford of Princeton University, who will be on ITER's technical committee, the reactor's pulses will last hundreds, if not thousands, of seconds.

That will provide the platform for ITER's science, which concerns the behaviour of one of the reaction's exhaust products, helium nuclei. If this very hot helium leaves the fusing hydrogen too quickly, it will not pass on the heat needed to keep the reaction going. If the helium leaves too slowly, it will dilute the hydrogen mixture; again, the result is that the reaction dies down. Yet, for the first time in fusion programmes, such science will have to share the limelight with the reactor's engineering—an indication (unwelcome to many fusion scientists) of the fact that fusion is nearing the day when it must appeal not only as an idea, but also as an investment for hard-nosed utilities companies.

One indication of the importance of engineering lies in the reactor wall and the blanket that surrounds it. At the moment, the design of the reactor wall limits the energy that can be drawn from the machine's core. According to Ronald Parker of the Massachusetts Institute of Technology, better techniques for extracting heat could treble the output of ITER to 3,000 megawatts—equivalent to a large, modern power station. Then there is the problem of the blanket, a fiendishly complex structure that (besides making steam and tritium) will absorb neutrons, a second product of the fusion reaction. Over a reactor's lifetime, these neutrons will make the blanket highly radioactive—exactly how radioactive depends

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critically on the blanket's materials. For example, steel, though cheap, would become thousands of times more contaminated than expensive silicon carbide. As fusion moves towards generating real power, such choices will become the bread and butter of fusion research.

Even after 40 years of work it is too soon to say whether fusion will be cheaper than other energy sources that do not depend upon fossil fuel. Today's best guesses suggest that energy from fusion could be three times as cheap as energy from other sources, but then again, it could just as easily be three times as dear. Given that the world spends $1 trillion a year on energy, the possibility of vast savings and the wisdom of buying insurance, against the danger that continuing growth in the use of fossil fuels will one day become unacceptable, are together a strong argument for the $300m a year that will be sunk in ITER over the next three decades. That said, fusion scientists are already emphasising ITER's "scientific" nature—a dangerous sign that they are ready to postpone an economic assessment of their art.

The truth is that ITER's successor (if it is built) will be a prototype commercial fusion reactor. It cannot be built unless plenty is understood about the economics of fusion. As other energy technologies evolve, fusion scientists will have a lot of competition in the race to become oil's usurper. The combination of all the world's major fusion programmes into one machine called ITER is a sign that they realise their money is short, though it is no guarantee that it will be well used.