

Tracking nuclear decisions (1)

JET: will it ever get started?

Chris Sherwell traces the tortuous course of a decision the EEC cannot take

WHEN, on the last day of last month, Mr Gaston Thorn relinquished the presidency of the EEC's Council of Ministers, he was frustrated and dissatisfied. The inertia paralysing the Community, he indicated, could be relieved by a move in the Council away from unanimous voting. It was the echo of a view expressed in many quarters many times before, though not perhaps by so senior or so obviously political a personage as the Luxembourg Prime Minister.

The widely-praised Heads of Government meeting two weeks later provided a much-needed boost for the Community. But its upper echelons are plainly troubled. Herr Guido Brunner, European Commissioner for Research, gave vent to his feelings when he visited London earlier last month. He too spoke of majority voting. But he had a specific matter on his mind—the Joint European Torus, JET. JET represents the next stage in the Community's effort to harness the power of nuclear fusion (see box, page 341). It also offers a remarkably fine illustration of what torments men like Gaston Thorn and Guido Brunner, not to mention scores of Community officials and countless people in the nine member states.

The immediate problem is that the Nine cannot agree to go ahead with the project without deciding on where it should be sited. The latest effort, at last week's meeting of the Council of Foreign Ministers, produced a piece of diplomatic mystification: the European Commission had asked for a decision of principle, before the summer recess, on the building of JET. This, it was thought, would facilitate a decision on the site when the Council of Research Ministers meets in October, and thus help prevent a split in the JET design team.

But the delays which have brought matters to their sorry pass were not ended. The Foreign Ministers watered down the Commission proposal, deciding merely to "adopt a favourable opinion on the rapid undertaking of the enterprise", which they thought should be put before the next Council of Research Ministers meeting for a decision. In short, the ball was put right back where it had been before, in the Research Ministers' court, and without any further movement over the site. This means that when a decision on where to site JET comes in October

—if it comes then—a full year will have been lost on a programme in which time is regarded as being of major importance.

What makes things worse, however, is that there must be some doubt attached to the prospect of an October decision for the precedents are truly inauspicious.

Euratom infusion

The Community's Fusion Programme, under the overall directorship of Signor Donato Palumbo of Italy, has its origins in the 1950s with the formation of Euratom and the EEC itself. Two five-year programmes were implemented between 1958 and 1967; work continued on a year-to-year basis between 1968 and 1970, when a third five-year programme was agreed. Once it was appreciated that, with the progress being made in fusion research, plans to build a large Tokamak—JET—could only be realised through an EEC-wide effort, a European design team of more than 50 members was brought together. The overall EEC fusion effort was co-ordinated by Euratom through a complex bureaucratic web of steering committees; JET is its centrepiece.

The laboratories at Culham, near Oxford, were offered as a location for the JET team. They form the United Kingdom Atomic Energy Authority's fusion research centre and, in the words of a Culham man, were offered "without prejudice to the final decision on the site for JET", which it was expected would be made by the end of 1975, when the original two-year contracts for the team's members expired.

All the advice the European Commission received in its wide consultations on the project acknowledged the risk attached to it, but the response was positive and members of the European Parliament gave their backing. So, with progress on the conceptual design of JET—a design which received additional backing at international meetings—the new overall plan for fusion research for the next five-year period (1976–1980) was put forward.

The total fusion effort for the period was put at 246 million units of account (mua). The estimated cost of the JET project was 135 mua—£80 million; the Community as a collective accepted responsibility for 80% of this (108 mua); member states would contribute the balance in proportion to GNP. Of the £80 million, some 21½% would go

on the JET device itself, 23½% on manpower, 17% on power supplies; the rest was for buildings (11½%), auxiliary systems (6¼%), the operating budget (6½%), instrumentation (5¼%) and contingencies.

As long as all these details were busily working their way up through committees towards the key arena of the Council of Research Ministers, and the customary problems involved in setting up a Council meeting persisted, a quick decision was not possible. With the putative deadline of 1976 looming closer, efforts were redoubled to secure a commitment on JET from the Council. But the Council of Finance Ministers, meeting first, would not decide on a financial allocation for a project on which a decision had yet to be taken. The Commission, facing the prospect of a sanctioned project not going ahead in the absence of a budget, obtained money to tide things over from the European Parliament under a special provision. It was a foretaste of the degree to which the Commission's ingenuity would be taxed. The Research Ministers finally met in December. And at that point the trouble really started.

See the sites

The meeting provided the first real indication that the Commission had completely underestimated the political problems involved. It emerged that Britain, with Culham, France, with Cadarache, West Germany, with Garching and Jülich, and Belgium, with Mol, all thought their own sites were suitable for JET. Italy, pushing for the Italian establishment of the Community's Joint Research Centre (JRC) at Ispra, refused to approve the whole 1976–1980 research programme in thermonuclear fusion and plasma physics unless a decision on JET's site was taken at the same time. No decision was taken, the programme was not approved, and the meeting broke up. Ahead of the next meeting, set for February, the Council's Atomic Questions Group exchanged views, and the Committee of Permanent Representatives examined its report, without taking anything further.

The difficulties were quickly compounded. Italy, having sought bilateral talks on the matter, failed to persuade Britain to support Ispra, and the British government started disclosing its own pro-Culham position publicly in the House of Lords. West Germany reasserted its willingness to take on 15% of the project's overall costs if Jülich or Garching was chosen as the site. Researchers at Culham reportedly began writing to Brussels urging an early decision.

That was not all. In late January, the Commission released the results of its

Confusion profusion: the arguments about the site

"If JET goes to Ispra, it is better that it does not get done at all." **Senior official, Culham fusion research centre.**

"If JET does not go to Ispra, it is not worth doing." **Senior official, European Commission.**

Culham and Ispra are probably the two main contending sites for the JET project. France's involvement in the Superphénix fast breeder is thought to make its bid for Cadarache more an attempt to score political points than a determined effort to win the project. Garching's candidacy is regarded with more severe respect and remains a powerful contender, but it has not planned to take JET in the way that Culham, with the design team, has done.

Only Italy defends Ispra with vigour; apart from Britain, though, none of the Nine openly backs Culham. The arguments concerning all the sites are finely balanced. The technical assessment of the Commission's site committee looked at the alternatives in terms of power supplies, infrastructure, safety and social facilities. On each criterion each site was fair to excellent: no site was best on all aspects, but all sites were suitable for the construction of JET.

It was chiefly on the power supply and social aspects that the Commission originally chose Ispra. It is fed directly from a conveniently located power supply; it already has an adequate infrastructure and social facilities, including an international school; it has staff already available for the project; and it has the equipment and expertise needed for the heavy engineering involved in handling large-scale plant and materials.

But the arguments in favour of Ispra now, if they didn't do so before, traverse broader territory than this. Perhaps the most potent actually comes from its supporters in the Commission itself, representing the collective Community interest. It is in the best long term Community interests, the argument goes, that the project be pursued as a Community effort. The project, particularly as it is largely Community financed, should therefore preferably be sited at a Community centre. And the premier establishment of the Community's Joint Research Centre (JRC)—indeed the only one capable of handling the project—is at Ispra, in northern Italy.

The argument goes further, into psychology. Ispra, it says, has been dogged by uncertainty in recent years,

and the latest programme of research is due to end this year. Although much of the multi-annual programme planned for 1977–80 will be conducted at Ispra, JET would insure its own future as the Community's leading research centre, which might in turn halt the fragmentation of research. Siting the project at Ispra would at the same time compensate Italy's loss by its exclusion from the UK–West Germany–Netherlands Gas Centrifuge Treaty for Uranium Enrichment.

The case against Ispra has come mainly from Britain, a point that has not gone unnoticed amongst senior Community officials. It turns most importantly on the project's chances of success. The chief scientist at the Energy Department, Dr Walter Marshall, not known as a fusion enthusiast, puts it this way: there is "an appreciable chance" that the project will fail, not because it is badly conceived but because it is so ambitious; it should not therefore go to any site which "lacks experience and know-how in solving the plasma physics problems that are bound to arise." Ispra's fusion experience (often described in Britain as "modest") is not great.

Marshall does think that the project should go ahead. But he judges that other sites, including Culham, satisfy his criterion in a way that Ispra does not. Moreover, he is "very much frightened" that if the counter-arguments about symbols of European collaboration win the day, then the project really will be a failure. If he could be persuaded of the scientific capability of a site, he has said, he would recommend it, but this he says has not been done; there had only been a "review of the characteristics" of the sites.

The implication is that a site (like Ispra) ought not to be chosen for an additional reason—to solve an administrative problem. Others allege in addition that Ispra's resources, and its capacity to get them, are not great. It has even been said that scientists would be reluctant to work at Ispra, especially as it has not managed a large project before. Past labour problems add to its reported reputation for mismanagement—a reputation also pinned on the Commission, whose allegedly closed mind over the matter has proved a sore point in Britain. That Ispra could prove to be the most expensive site, which is also suggested, is a point that Guido Brunner, European Research Commissioner, disputes. He

says the differences in cost between the various sites is no more than 10%.

The arguments in favour of Culham are partly the arguments against Ispra reversed. Culham, it is said, is already a centre of excellence in fusion, commanding large experience and resources, possessing a good "track record" and making progress that is more than comparable with the USA and USSR. Furthermore, it not only fits the bill on such essential criteria as power supplies, it also has the land ready to take JET and, most importantly, a team already settled there to continue the work it has successfully begun. Such continuity, it is argued, ensures the maximum chances of success. Culham, says Alex Eadie, junior minister at the Energy Department, is the best site on technical, scientific and operational grounds. But another reason offered in support of Culham is more nakedly political: namely, that there is as yet no high technology Community project in Britain. This gives it some sort of advantage over Garching, for example, since West Germany has the Patent Office and the European Molecular Biology Organisation.

Arguments against Culham throw doubts on its back-up facilities, on the lack of a school and so on. Beyond these, though, it is said that expertise in fusion is not really relevant for much of the project's duration, since most of the time would be spent in JET's construction; moreover, any problems that arose would probably be too big for any one laboratory to solve alone. More subtle arguments point to the recent experience with the Dragon high temperature reactor project at Winfrith, Dorset, during which Britain attracted from many European countries criticism of its foot-dragging, if not obstructionist, tactics over the project's fate.

The site stand-off preventing JET's take-off is thus a complicated affair. It has tried the patience of the contending host countries, whose Community spirit is already under scrutiny. It has aggravated the frustrations of the smaller member states who these days have enough reason to feel left out in the cold. And it has threatened the role of the Commission, whose ambiguous position has rendered its influence and authority more tenuous than it might otherwise have been. The Community's worst enemies couldn't ask for more. □

independent siting committee. It had not previously pushed any one site; now it came down in favour of Ispra. Moreover, it delivered its view as a communication instead of as a "proposed decision" for the Council, as was customary; this it defended by saying that only the whole project, including the matter of the site, and not the site alone, involved a decision. The boundaries of the Commission's competence to decide on the matter thus became an issue as well.

The February 24 meeting of the Research Council began by avoiding an immediate break-up over the site. British, French and West German pressure wrought a reduction in the total fusion budget from 246 mua to 232 mua, thereby leaving less for the fusion research not directly related to JET. This, however, entailed the abandonment by Italy of the position under which she had linked a decision on the site with approval of other fusion research programmes; but she still insisted, successfully, that the meeting sanction just one year's expenditure—20.8 mua. But that at least meant the programme could go ahead.

When it came to discussions of the site, however, none of the contending countries withdrew their applications to host the project. After hours of debate, the Ministers failed even to agree on a method for deciding where JET should go. They rejected a proposal that the Commission, as the competent authority, should decide, and also the idea of an exhaustive ballot among themselves. Eventually, applying an old adage ("When in doubt, never commit yourself, committee yourself"), they agreed to call for a new report on the alternative sites. This was to come from a special committee established by the meeting, the Consultative Committee for the Fusion Programme, consisting of a representative from each of the Nine, a Commission representative and representatives from third countries involved in the fusion programme. It would report on comparative technical merits in May, in time for the next Council meeting, set for mid-June.

Some states openly regarded this as a waste of time; Italy hoped that the question of the site would not be reopened. For the Commission, Brunner still claimed the matter was within its competence: he couldn't see what new light would be thrown on the problem by more technical assessments; only something very dramatic could change the Commission's mind. For all its immobility though, the Commission did not apparently intend to try and impose its choice.

By now the threat of rising costs was starting to make speed vital; so too was the ground being lost against the USA and USSR; and the team's declining

morale, with the increasing prospect of its break-up in spite of a renegotiation of contracts for a six-month extension. But the rest of the fusion programme was assured for a year; and the new committee had also been accorded a general role in respect of the whole programme, which would help its development. All the same, it looked as though the JET problem was so intractable that it would need resolution by the Council of Foreign Ministers or by the nine Heads of Government—a suggestion which the Dutch had by now put forward.

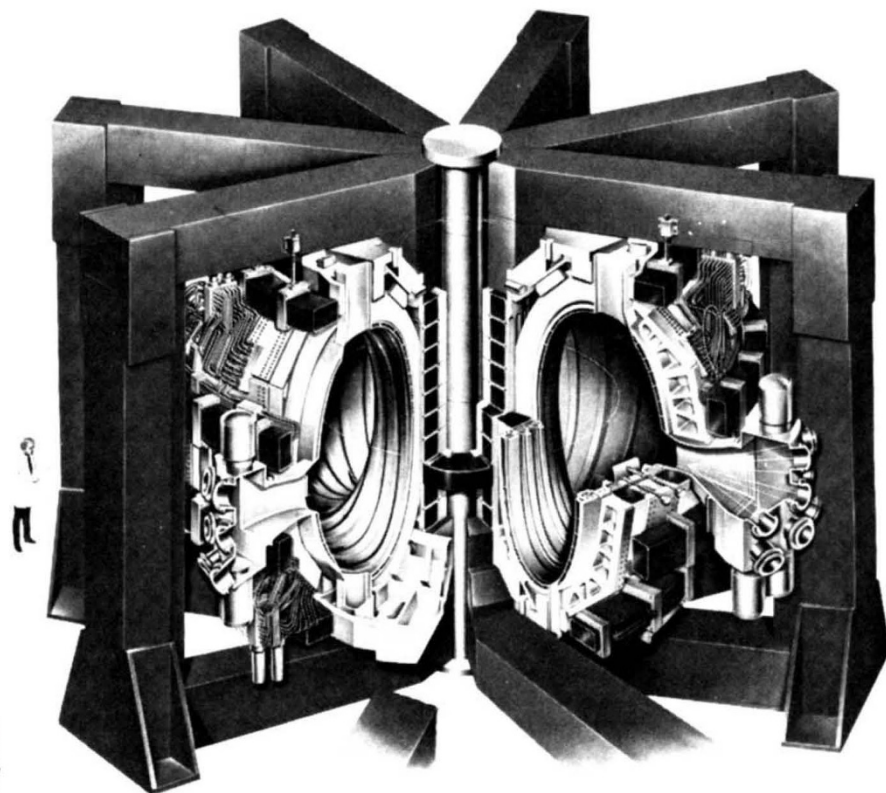
Fight goes on

With the fighting now well developed, two sites were withdrawn—Mol in Belgium and Jülich in West Germany. Reports of job offers from the USA for members of the design team grew, and a few actually left the project. Britain made a climb-down more difficult when she put her view favouring Culham to the House of Commons in March. The "common front" of trade unions at Ispra called a press conference later that month to urge a decision in favour of Ispra and of a Europe independent in energy and science.

The Consultative Committee, at its first meeting in early April, received an independent report on JET's design details from the UK-based Risley

group. This confirmed the team's plans, and the Committee recommended that a decision to build was needed forthwith. It recommended too the immediate creation of a management committee for JET together with a strengthened fusion directorate at the Commission. But the Committee also heard estimates that certain costs had drifted upwards, making overall costs some 23 mua greater than the original 135 mua. Another meeting was set for mid-May to discuss a final report following consultations with the JET team over the Risley report. Incredibly, the Committee did not discuss the matter of the site.

Neither was it discussed at the Council of Foreign Ministers meeting in early May, even though Luxembourg, backed by Belgium and Holland, was trying to put it on the agenda. In fact the agenda was already too full. The lack of movement encouraged some European parliamentarians to speak out volubly, questioning whether European collaboration was possible, and whether latest estimates of Europe's future energy requirements didn't tilt the balance one way or the other. In mid-May Brunner signed the draft agreement on Sweden's participation in the fusion programme; negotiations with Switzerland, something which with the Swedish precedent was not expected to take long, were almost



EEC picture

JET: an artist's impression

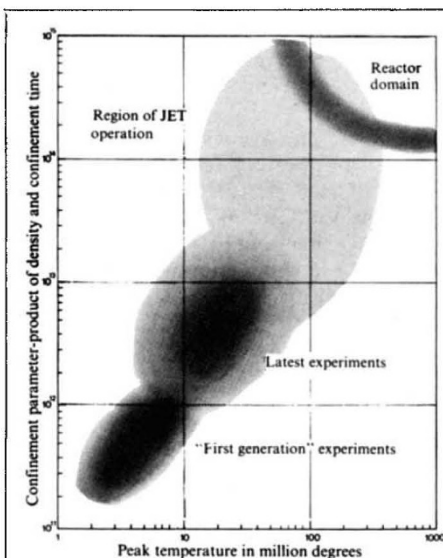
ready to commence and soon received the go-ahead. The pace was quickening again.

The Italian general election, set for June 20, just two days after the crucial Council of Research Ministers meeting, now intervened. With the prospect of an upset result producing an Italian government which might disagree with any decision taken by the Council, it began to seem pointless having the meeting at all. At Italy's request it was decided that the meeting would not take place. The Dutch proposed a meeting for mid-July; this was agreed in principle. As late as the first week of June, Brunner was expressing the hope that a decision on the site would be taken at such a meeting. Days later it was clear that no meeting was likely before the summer recess. No early decision on the site would therefore be possible unless the idea of a determination by the nine Foreign Ministers was resuscitated.

The Commission had itself come round to this view. It had also been busy on the central problem of the site: by the end of May it had finished preparing additional information for the Council of Research Ministers in order to make the choice easier. This included, first of all, the news that consultations concerning the higher cost estimates had produced agreement that the extra amounts involved were in fact negligible, at about 5 mua. The Commission also contended that insufficient emphasis had been attached previously to the matter of the power supply: if JET was to be fed directly, Ispra, fed by a line from a thermal and a hydroelectric station, possessed another advantage over other sites. Finally, the Commission stressed the costs of delay. Increasingly frustrated, it therefore argued that no attempt to justify a further delay could be based on arguments of a scientific, technical, financial or administrative nature.

With no prospect of a meeting of the Council of Research Ministers before mid-October, and the need for decisions growing more desperate, it was now time to change tack. At the end of June, therefore, and at the request of the Dutch (who were about to take over the Council presidencies), the nine Foreign Ministers had a brief exchange on the siting of JET. The Commission was now looking for a decision of principle on the building of JET before the recess in order at least to supply more adhesive to the JET team than the second six-month extension to contracts just put together.

The matter was put on the agenda of the Heads of Government meeting on July 12. The boost they were busy giving to the Community did not extend as far as JET, however, and it was not discussed. Assurances were



Fusion research: where it's at

FUSION research, which seeks to harness the energy released when nuclei of light elements are brought together to form heavier ones, aims ultimately to design a practical fusion reactor that produces electricity economically. The aim is thus to approach more closely the conditions at which the energy released from the deuterium-tritium reaction (the fusion reaction selected as the most promising of several possibilities) is greater than that expended both in heating the plasma in which the reaction occurs, and in losses.

The immediate goals are therefore to find ways of heating the plasma to the necessary temperature, and to confine that plasma for the necessary time. Apart from the passage of electric current, methods of heating currently being investigated include the use of intense laser beams and the use of beams of high-energy neutralised particles originally produced from an ion source. The method of confinement in a doughnut (torus) shape uses a helical magnetic field. This is made up of two components, a toroidal field produced by large external coils, and a poloidal field which, in the case of tokamaks like jet, is produced by a toroidal current in the plasma.

Tokamaks, however, represent only one of three classes of toroidal device now being examined for their confinement capabilities. These are in fact distinguished by the way the poloidal field is produced:

(a) **Tokamaks, and Reversed-field Pinches** (high beta systems). In tokamaks the toroidal field is greater than the poloidal field; in reversed-field pinches the two are about the same and the toroidal field is reversed in the outer

regions of the plasma. In both, the plasma current which heats the plasma also creates the poloidal field.

(b) **Stellarators** (low beta systems). In this class of device, currents in helical conductors wrapped round the torus and outside the plasma produce the field which, with the toroidal field, confines the plasma.

(c) **Toroidal multipole.** Here the poloidal field is produced by a steady current flowing in a levitated superconducting ring located in the centre of the vacuum chamber with the plasma.

Magnetic confinement produces a plasma of modest density, so the confinement time necessary to boost the "confinement parameter" (density x confinement time) is longer compared to a plasma of very high density.

Obtaining a high-density plasma is the aim of inertial confinement, in which the necessary time of confinement is actually shorter than the period in which the particles will escape from the reacting zone. This confinement is achieved by irradiation with high-power laser beams. Extremely intense, short laser pulses bombard a solid deuterium-tritium fuel pellet, causing it to turn into a plasma so hot and so compressed that fusion reactions yield a surplus of energy before the pellet decays as a result of expansion. The method does not simply offer the possibility of avoiding the difficulties of using magnetic fields for confinement; it also offers the theoretical possibility of using a series of laser pulses to cause a succession of these explosions.

The selling of fusion power has turned largely on its ostensible advantages in respect of the fuel it uses and its safety. But the supply of lithium (used to produce tritium) is at least not certain, and neutron production in the reactor has the potential to make the reactor materials highly radioactive. There are other problems relating to possible lithium fires and tritium leakage. And since fusion is so patently a prospect for the distant future, guesses about its economics remain exactly that—all of which makes any choice between fusion and fast-breeder fission, if such a choice exists, correspondingly more difficult to make.

JET is effectively a "third generation" tokamak device. Its equivalent in the USSR is known as T-20, in the USA as TFTR, and in Japan as JT-60. "Second generation" tokamaks include DITE at Culham, T-10 in the USSR and PLT in the USA.

For the post-Jet period, the following sort of sequence is imagined:

- 1980-1985 Tritium burning experiment
- 1985-1990 Experimental reactor
- 1990-2000 Prototype
- 2000-2010 Demonstration

Other common facilities envisaged over this period include a material testing facility and a superconducting magnet assembly.

given that last week's Foreign Ministers meeting would deal with the matter in some detail though it was not on the official agenda. Nothing approaching progress which would satisfy the Commission resulted. The recess is now imminent. October is two more months away.

JET lag importance

The persistent procrastination, far from indicating that the EEC perceives the JET decision as having comparatively minor consequence, is precisely a reflection of the project's importance. JET is a major Community research project, perhaps the first of its type,

perhaps the first of many. Money is to be spent, and there are contracts to be had. That means large and powerful interests are involved, not just on both sides of various sectors of manufacturing industry, but within state administrations and institutions and within the EEC's own administrative structures.

With so much at stake, the decision on the site had to become the prime focus of interest. To win JET was (and is) to win fusion in Europe. There are some, notably the Italians, who have claimed that JET, being just one part of an even larger overall programme, would not by its location determine where the European centre of excellence would lie. The argument is that the other projects to come would be sited elsewhere. But no one seems to believe it. Whoever wins JET, most are saying, acquires the huge investment that goes with it, the location for future reactors and the investment that goes with them too; whatever the spreading of the contracts, and no matter what clauses are inserted as safeguards into the agreement, the host country is said to have the advantage. That country's cap acquires the fusion feather—and the reputation, the prestige and the national pride. It seems rather a lot to hang on a unanimous decision of a group of Research Ministers.

The Commission, in the form of Signor Palumbo, finds all this a trifle exaggerated. He claims that the press has "transformed a technical and limited problem into one of prestige", and points out that there is another aspect of the problem beyond the interest of a country in having JET. This is the interest in having JET at the best possible site. Suppose, he says, a super-intelligent, objective man

could identify both the best and the worst sites among those competing for JET. The difference between the value of the best site and the value of the worst site, he argues, is hugely outweighed by the damage done by a one-year delay to the JET project and to the common fusion programme. Indeed, all sites could host JET. The choice of the site, while blocking everything, is thus irrelevant, he claims, and he goes on the repeat the growing view—that if the Commission's choice is not approved, the Council of Ministers must give up its jealously guarded unanimity rule to come to a definite choice.

He certainly seems to be right about the urgency. Existing programmes for medium scale devices at Jülich, Cadarache, Garching and Culham all depend technically and financially on a decision on the site for JET. Delay is discouraging the JET staff even further, making it difficult to maintain the team and impossible to expand it. It has been possible to farm out some small study contracts relating to the project, but money available for this is almost totally spent, and a Council decision is required for more. Plans for buildings cannot be finalised, of course, buildings cannot be built, and orders cannot be placed for equipment that might be unsuitable or superfluous if another site is chosen. As the Commission has itself put it, any decision concerning further work without the site being known would be unrealistic, perhaps dangerous and almost certainly expensive.

Just how expensive is perhaps not appreciated. The delay, apart from jeopardising the project itself and the whole fusion programme, may now be jeopardising the spirit of cooperation

that exists in Europe. It may also be damaging the credibility of the Community's decision-making procedures among other international organisations and in other non-EEC countries. Most importantly, it may soon start affecting Europe's own public, whose tacit support for the expenditure of so much money is less likely if the persistent delays (and the corresponding progress of the Americans and Russians) make the project seem pointless.

Optimists point out that a decision in October would mean that a delay of only a year had been incurred. No decision in October might mean leaving the decision as late as the next Heads of Government meeting in The Hague in December. But the viability of the whole project may have been brought into question by that time; as Herr Schuster, Director General at DG XII in Brussels, puts it, if there is no decision by then, the project is dead in an EEC framework. Yet it is Schuster who freely acknowledges that the German elections later this year might intervene, Italian-style.

An alternative has already been mooted: that JET becomes a British-French-German operation. But a British minister has already said Britain is committed to European collaboration. And the Commission heaps derision on the idea. Alternative combinations, it is said, are "futuology": the three countries can't agree among themselves, and JET is anyway "owned 100%" by the Commission. But political facts could conceivably change things. The Community is being brought into disrepute. Fusion itself is being brought into disrepute. Unless something is done, a Community fusion project might therefore be a forlorn hope. □

Tracking nuclear decisions (2)

FBR: will it ever be stopped?

Allan Piper looks at the arguments concerning the fast breeder reactor

THE UK Energy Secretary, Anthony Wedgwood Benn, decides this autumn whether Britain will build a commercial scale fast breeder reactor. It is a measure of the task he faces that, from one viewpoint, the FBR is an elegant and timely solution to immediately foreseeable energy problems, while from another it looks like potentially the most disastrous technological development imaginable. The dichotomy is simply explained: the reactor's most attractive advantage—an ability to create its own fuel—is precisely its major disadvantage. For the fuel so created is plutonium, the stuff

of nuclear weaponry.

Mr Benn is fully aware of the enormity of his decision's implications, whatever he chooses. Not much is known of how he will reach it, beyond the fact that a certain amount of public debate is involved. Some people believe the decision is being taken too quickly and ought to be delayed, saying the FBR is not yet needed; others contend that an early decision is vital for the industry and the country. The arguments are complicated, but what Mr Benn has to decide is, first, whether fast reactor technology is an essential element of the future energy scene;

second, whether it can be developed to an acceptable level of safety; and, finally, whether it is socially desirable. He must make his decision against a backdrop of clear signs that the FBR will be developed elsewhere if not in Britain, and delay could spoil the chances of an early foothold in a potentially lucrative worldwide market.

The case for the FBR rests squarely on its fuel breeding capacity (see box, page 344). Unlike existing commercial thermal reactors, which use less than 1% of the energy available in uranium, the FBR extracts more than 60%. At the same time it contributes towards future energy supplies by "breeding" plutonium. These simple advantages mark it out as the potential saviour of an energy hungry world.

Consideration of Britain's nuclear fuel prospect highlights the possible benefits of the FBR. Since the middle 1950s the UK thermal reactor pro-