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BRITISH EMBASSY,
PARIS.

FROM THE AMBASSADOR

10 July 1989

CDP 12/7.

C D Powell Esq
Private Secretary to
the Prime Minister
Prime Minister's Office
No 10 Downing Street
LONDON SW1A 2AA

My dear Charles,

1. When Crispin was here for a Sherpas Old Boys' dinner, Michel Rocard asked to see him, as an old friend. I went along too, and Crispin and I thought that, while others in London were looking at the result, you might like a blind copy for your own information.

Yours ever,

Ewen

Ewen Fergusson

RECORD OF A DISCUSSION BETWEEN THE FRENCH PRIME MINISTER AND SIR CRISPIN TICKELL, MATIGNON, 10 JULY

Present:

Sir Crispin Tickell	Monsieur Michel Rocard
Sir Ewen Fergusson	Monsieur Philippe Petit

1. Sir Crispin Tickell called on the French Prime Minister at the latter's request for a discussion about global climate change. Their conversation lasted about 40 minutes.

2. M. Rocard spoke of The Hague Declaration and the institutional ideas in it. He would not, he said, be satisfied with institutional machinery which would give a veto to any single country. He accepted that an institutional authority on global climate change should derive from the United Nations and the World Meteorological Organisation. He agreed there should be much greater exchanges of information. Nevertheless some decision making machinery would be required. He agreed that there should be reflection about the means, but he did not think it possible to avoid the use of majority decisions.

3. Sir Crispin Tickell said there were three priorities: negotiation of a convention, institutional arrangements, and the action which should follow. He reported on the Prime Minister's April seminar, his own speech to ECOSOC on the international aspects on 8 May, and our discussions with the Russians in Moscow on 3 and 4 July. Soviet approach was threefold: conceptual, political and practical. It made good sense. For our part we believed that little could be achieved without a common scientific base. However we attached particular importance to the conclusions of the Intergovernmental Panel on Climate Change (IPCC). We did not want to frighten the world with too much too soon. That was why we did not like the references in The Hague Declaration to such things as recourse to the International Court of Justice, majority voting, compensation etc. For example there had already been an initially negative reaction from the Brazilians. But Mr Chris Patten (ODA) had been to Brazil and had negotiated a valuable practical agreement with the Brazilians on the rain forest.

4. Sir Crispin Tickell continued that we put our emphasis on negotiating a convention and supporting the work of the Intergovernmental Panel. We thought it best to make use of existing institutions, including possibly the Security Council. We could see whether the Intergovernmental Panel might not be continued after the submission of its report in the guise of

/Intergovernmental

Intergovernmental Commission under the authority of the Security Council. It should go without saying that Britain and France were in a particularly strong position at the Security Council. To create an entirely new institution would take a long time and run into every kind of trouble (including who should belong to it and who should exercise what powers in what conditions). Instead we should make use of what exists. He found that the use of the word «compensation» to poor countries in The Hague Declaration would cause us, and probably others, considerable difficulties; it would be tantamount to writing the non-industrial world a blank cheque. The first step was for the industrial countries, who had unwittingly created most of the problem, to give leadership and admit the principle of giving help to others. In the immediate future they would have to work by example more than preaching to others. But the problem was global, and eventually there would have to be global arrangements.

5. M. Rocard said that as far as he could judge there was only one major disagreement between us: the urgency of the problem. He had been surprised at the speed of agreement at The Hague. He believed that there was a growing sense of emergency and that technical progress would impose the need for uniform standards over the next two years or so. If we thought that was premature, others did not. The francophone African countries had now joined their names to The Hague Declaration, as also the Arab League. Since The Hague Conference the five members of the Community who had not then signed had signified their agreement. It was as well they had agreed later to avoid the reproach that The Hague Declaration was dominated by the Europeans (a point of particular concern to India). Only Britain now stood out. Switzerland, Austria, Iceland, Czechoslovakia, Poland, Pakistan, Bangladesh, Guinea and Israel had now signed up. The terrain was more favourable than the British still seemed to think. He hoped that HMG would continue to look at the possibility of joining. The last thing that he wanted was continuing disagreement between us.

6. Sir Crispin Tickell said that it was true that there was still disagreement. We had not signed The Hague Declaration and would not do so. But we were anxious to work with the French on what now lay ahead. M. Rocard agreed that we should work together. He hoped that there could be contact between British officials and The Hague Secretariat on the drafting of the convention. There was much in common on practical aspects.

7. Sir Crispin Tickell said that Britain was the Chairman of one of the working groups of the Intergovernmental Panel, and had been especially charged to put together the elements of a convention. Naturally we were in touch with other countries, including some of the signatories to The Hague Declaration, and would take their views into account. The

/fundamental

fundamental difference between us at the moment was less over the nature and urgency of the problem than about how best to make progress in dealing with it. We believe that without a reasonable measure of scientific consensus, it would be difficult for governments to take the necessary decisions. It was all too easy for people to sign declarations. We had to get down to the practicalities. A number of ideas were under consideration, for example a carbon tax had been mentioned in a paper recently published by the Centre for Policy Studies. This might not run, but all the possibilities needed to be explored. In the meantime we needed to work together in New York. There would be a General Assembly resolution this year, as there was in 1988, and we did not want to open up differences between countries who were united on essentials. Last year he had set up a group of environmentally interested Ambassadors to pilot through the main resolutions on this subject. Unfortunately the French, although invited, had decided not to participate. This year we were doing the same. The French were participating, and we hoped to have their full help and cooperation.

8. M. Rocard said that we could work on some step by step mechanism, and defer looking at institutional arrangements until the phase of scientific analysis had been carried further forward. Nevertheless there was both a need and a demand for institutional progress and for some arrangement for compensation. We might not like the word but there had been heavy pressure in this respect from India and Brazil. We in the industrial West must show that we were ready to be responsible for more than proportional help. In any case The Hague Declaration was essentially a mandate to open negotiations, not a definition of their final outcome.

9. Sir Crispin Tickell said that even the use of the word «compensation» would start things on the wrong footing. India and Brazil among others were asking for payment not to do things which it was already in their own interest not to do. They would suffer as much as anyone from global climate change, not least because the monsoons might become irregular. Any country with a large land area and dependent on seasonal rainfall, like the Chinese, would be at particular risk. So it would be better to avoid talk about compensating people. Certainly we should give help; but that was a different issue.

10. M. Rocard admitted the existence of the problem and said it reinforced the case for further diplomatic cooperation. Sir Crispin Tickell said that clearly no-one should exclude the development of further institutional machinery. But first we should concentrate on seeing what could be done with existing institutional instruments before tackling the difficult problem of what more might be required. M. Rocard said that it was a pity that there had been insufficient time for Mr Gorbachev to raise this issue with President Mitterrand. Sir Crispin Tickell said that nor had it come up in his meeting with Mrs Thatcher

/in April.

in April. But he had found it reassuring after Anglo-Soviet talks in Moscow last week that the Russians should be on the same wavelength. They had said that the Soviet government would not sign The Hague Declaration but that it would be glad to find a point of convergence. The Russians also agreed with us on the advantages of using the Security Council in one way or another, but had mentioned the obvious difficulties. They were anxious to work closely with us. The trouble was that some third world countries were hankering after something wholly new. But something new could all too easily suffer the fate of the negotiations on the Law of the Sea and lead to 15 years of sterile argument.

11. M. Rocard said that it was clear from that what was needed was an intermediate agreement but one could not exclude from that a requirement for some new institutional machinery. Sir Crispin Tickell said that we were working to a clear timetable. First there was the forthcoming debate in the General Assembly in the autumn; next there was the submission of the report of the Intergovernmental Panel in September 1990; then there was the World Climate Conference; and finally there was the World Environmental Conference of 1992. We should take advantage of the three years ahead of us to conclude the convention, work out our ideas on institutions, and look towards action in the hope that all these could be settled at latest by the World Environmental Conference in 1992. Mr Gorbachev in his speech to the UN General Assembly last year had mentioned the idea of a Summit meeting of the main interested countries before 1992, but Sir Crispin Tickell noticed that the Russians had softpedalled this in their discussions last week. But it was not to be excluded. We now had to make the best of the timetable which lay ahead. Naturally the views of The Hague participants should be taken into account at every state.

12. M. Rocard said that clearly between now and the General Assembly in the autumn it would be helpful if we could see how far our ideas were compatible and we should work together. He specifically mentioned M. Jean Ripert as the appropriate point of contact with the French administration. M. Petit said that the scientific consensus might not be as complete as we would wish when the Intergovernmental Panel refronted next year. We could not wait for ever. Sir Crispin Tickell said that this was so. There were many scientific loose ends. Most of the modelling was inadequate. But we must make the best of what was available. M. Rocard agreed. He favoured close cooperation between us.

British Embassy,
PARIS

10 July 1989

scpu.

THE U.K. CENTRE FOR ECONOMIC AND ENVIRONMENTAL DEVELOPMENT

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Ms Caroline Slocock
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10th July 1989

Dear Caroline

May I first thank you for your part in organising my recent meeting with the Prime Minister. I wonder whether it would be more appropriate to send communications addressed to you, rather than directly to the Prime Minister. If your portfolio changes in the future, perhaps you could kindly advise us of the name of your successor.

I enclose two copies of the latest issue of our Bulletin which is a special issue on the UK's wider environmental role. You will see that it also reports briefly that my meeting with the Prime Minister occurred, without revealing the contents of our discussions.

One point which we did discuss was the "safety inherent reactor" concept. I enclose an article from the most recent issue of ATOM, the UKAEA's journal, which discusses this. The first part is somewhat technical but the closing sections discuss the general concept. I have also asked some of the partners in the consortium to send some material direct.

Finally, can I turn to a matter which I raised at the ministerial seminar on 26th April, when there was debate on whether private enterprise initiative alone could respond to environmental challenges. I mentioned then that a leading UK company had initiated some discussions with us on a novel approach to urban transport problems designed to address both congestion and pollution problems.

I can now reveal some more details, although I would be grateful if you could treat them in confidence. The enterprise is the leading car hire company, Hertz UK Limited. They now wish to take their ideas forward and have asked us to convene a small high-level discussion with the leading agencies, public and private, whcih would need to be involved if their proposals are to progress.

/cont...

I also mentioned the matter briefly to Mr Channon with whom I talked before lunch on April 26th and am contacting him to ask for his help in arranging the appropriate Department of Transport involvement. I thought, however, that the Prime Minister might like to know of this substantiation of my assertion that private enterprise <u>is</u> responding to the environmental challenge.

The additional attraction is that, through the company's international links, there might well be opportunities to export this UK initiative.

Best wishes

Yours sincerely

David R Cope
Director

Enc

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ATOM, the monthly magazine of the UKAEA, is available free. It is distributed extensively within the nuclear energy and electricity industries, both in the UK and overseas. Other recipients include the business and financial community, most MPs, universities, polytechnics, libraries, schools and members of the public.
For the period 1 July 1988 to 31 December 1988 inclusive, the audited average net circulation of ATOM was 12 810 copies per month (Audit Bureau of Circulations statement). Nearly 4000 additional copies of each issue of ATOM are also sent out each month. The bulk goes as multiples to particular recipients who distribute them to others. Several hundred of these additional copies go to the Central Office of Information for dissemination worldwide by UK diplomatic posts. Further stocks of ATOM are held for new readers, to meet requests for back numbers and for records purposes.

COVER ILLUSTRATION

Design of the Sir (small integral reactor), an integral PWR with core, steam generators, pumps and pressuriser all contained within a single pressure vessel. See feature, page 2.

ABC MEMBER OF THE AUDIT BUREAU OF CIRCULATIONS

The Sir project

The UK Atomic Energy Authority, as a member of a consortium of four US/UK organisations, has developed a design for a small passive light water reactor suitable for deployment in the late 1990s. The consortium is bidding for a USDOE contract to develop the design for generic licensing. Dr Mike Hayns of the water reactors programme describes Sir (safe integral reactor), the 320 MWe reactor unit that is the basis of the design being submitted.

INTEREST IN THE DESIGN of advanced, or next generation, nuclear plant is quickening as the combined impact of growing environmental concerns over burning hydrocarbons and the projected requirements for new plant take hold.

More parochially, in the UK, the privatisation of the electricity supply industry (ESI) provides an additional reason why a new design might find early commercialisation. While the development of existing reactor designs continues, there is an increasing interest in smaller generating plants that offer the advantages of low capital cost, greater flexibility and a potentially lower environmental impact.

A joint USA-UK venture (see box) has been initiated to design a small nuclear reactor which complies with these requirements and is geared specifically to the needs of the late 1990s and early 21st century. The lead unit of Sir (safe integral reactor) could be built at the UKAEA's Winfrith site (see ATOM March 1989 page 35).

The principal driving force for the project is to provide a reactor system which, while being based firmly on existing technology, materials and know how, offers radical solutions to the economics, licensing and acceptability of nuclear plant. In this there is common ground between the USA and UK.

The partners agreed at a very early stage that the smallest possible size which could be shown to be economic should be chosen. This is because we believe that there is considerable benefit to be obtained from modularisation and that a smaller size opens up a much wider potential market.

It was, therefore, for economic and market potential reasons as well as purely technical ones that a size of around 300 MWe was chosen. At this size a completely different approach from that of the traditional PWR is possible and it is the aim of this article to describe this approach and how it can be translated to give a practical and economically viable electricity producing reactor.

Technical description

Sir is an integral PWR in which the core, steam generators, pumps and pressuriser are all contained within a single pressure vessel. The containment is of the pressure suppression type with a novel concept of dispersed, steel suppression tanks.

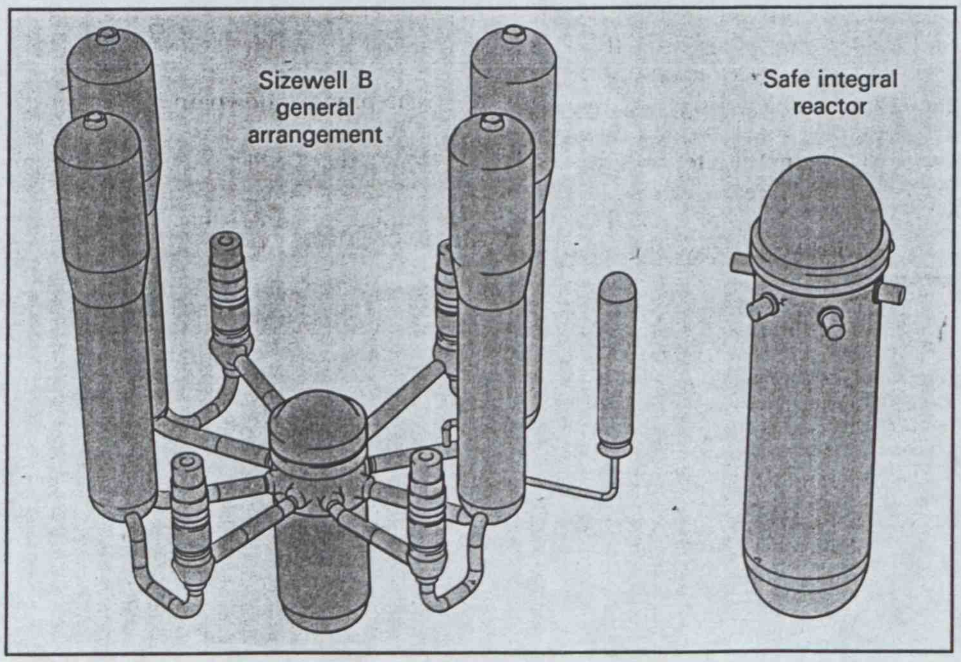
Pressure vessel

Figure 1 shows a current design of PWR (similar to that of Sizewell B) alongside the Sir reactor pressure vessel (RPV). In the standard design, the RPV contains only the reactor core. It is connected to the steam generators, the pressuriser and the pumps by large diameter pipework. In the Sir design all of these components are contained within a single vessel. This has very important consequences for constructability, operability and safety.

The drawback to the Sir type design is that a large station would need a very large vessel. Since we intended Sir to be geared for ease of construction and factory fabrication, this was not considered realistic. In figure 2 the Sir vessel is compared to the steam generator shell of a current Combustion Engineering designed system 80 reactor, and one from Sizewell B. It can be seen that the Sir RPV is approximately the same size and can therefore be manufactured using current techniques. Thus we have been able to use an integral design which is within current technology and is an economically viable proposition.

The main part of the vessel is 19·2 m long with an internal diameter of 5·8 m and a wall thickness of 0·28 m. It weighs about 907 t. The closure head containing the pressuriser region is 4·6 m high.

Figure 1. Comparison of a typical 4 loop distributed PWR design and Sir



Contributory partners to the venture

In the USA	**Combustion Engineering** US PWR designer whose units offer the leading capacity factor performance as confirmed by USNRC data.
	Stone and Webster A leading US/UK architect-engineering firm with major relevant nuclear/civil experience.
In the UK	**Rolls-Royce and Associates** The foremost UK PWR supplier with over 20 units completed and operational.
	United Kingdom Atomic Energy Authority Paramount in the UK for nuclear R&D, nuclear safety analysis, operating experience and training capability.

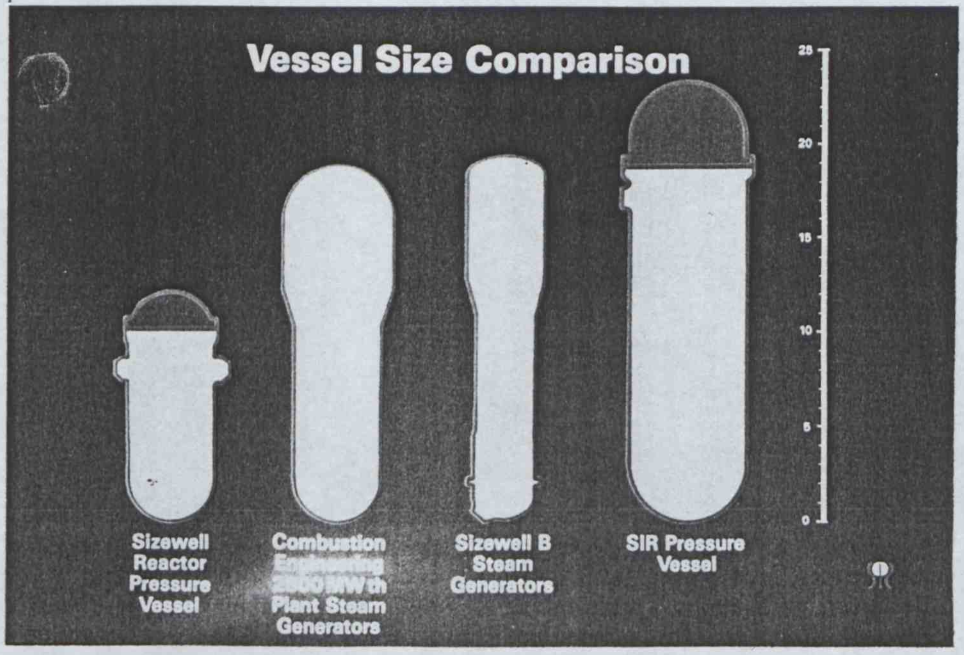
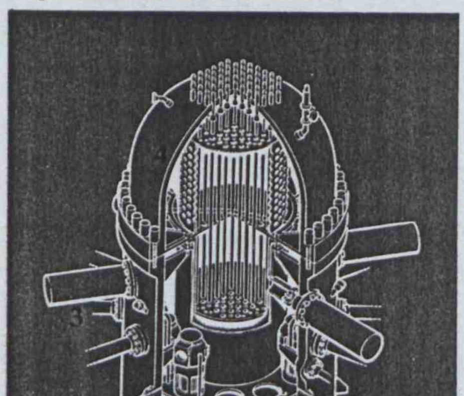


Figure 2. Comparison in size between the Sir RPV and other standard PWR components

Internal arrangements and flow paths

The arrangement of the internal components is shown in figure 3. The core is low down in the vessel. Control rods are driven on long drive shafts in an otherwise conventional PWR arrangement. Apart from the control rod drives and guides, the space above the core is left free for refuelling operations. Outside the core barrel is a ring of 12 modular steam generators. Sufficient space is left between them and the core to avoid high neutron activation levels in the lower part of each steam generator. There are six mixed flow pumps above the steam generators. The upper part of the vessel forms a pressuriser with electrical heaters to maintain the design pressure of 15·5 MPa.

Figure 3. Internal reactor pressure vessel components: 1. reactor core; 2. steam generators; 3. reactor coolant pumps; 4. pressuriser; 5. control rods



The primary flowpath is up through the core, through the pumps, down through the steam generators and back to the lower plenum under the core. The current design is capable of operating at 20 per cent of full power on natural circulation alone. The flows are shown schematically in figure 4.

Reactor core

The reactor core design is based on standard Combustion Engineering design practice. The fuel pins are Zircaloy 4 clad, 9·7 mm OD and 3·47 m in active length arranged on a square lattice in fuel assemblies. There is a control element assembly (CEA) for each fuel assembly, since soluble boron is not used for reactivity control in Sir. Spaces for each element of a CEA occupy four fuel pin spaces and reduced enrichment fuel pins are provided round these positions to avoid power peaks when the control rods are raised. Control rod drives are standard and are mounted on the vessel closure head. In order to provide an adequate ligament between head penetrations, the fuel assemblies are larger than normal, being on a spacing of 285 mm. These contain 432 fuel pins.

Avoiding the use of boron for long term reactivity control is very beneficial in that the complex chemical control plant is not needed, the chemical environment seen by primary circuit components is less demanding and, if absolutely necessary, injection of boron can be held in reserve as an ultimate (and diverse) shutdown device. Instead of boron, long term reactivity control is provided by burnable (solid) poisons. Some of these are fixed in the new fuel elements and others are inserted to give control during the second and subsequent operating cycles.

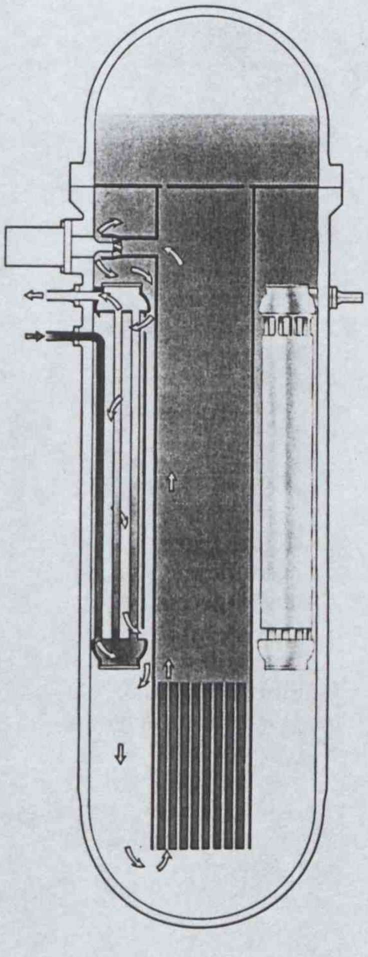


Figure 4. Primary circuit flow diagram

The mean power density in the core is only 54·6 kW/l. This is about half that of current large plant and makes an important contribution to increased safety margins and operating flexibility. Furthermore, it means that the refuelling cycle is longer than for higher rated cores (two years compared to typical values of 12 to 15 months). This allows a much higher and more efficient target load factor of 87 per cent.

The power density in the Sir core and a number of important reactor system parameters are compared with those for current designs in table 1.

The core is supported by the core support barrel assembly which also follows standard CE design practice. It is held down by an extended holddown structure which in turn is held in place by the vessel head closure.

Refuelling is carried out off load with the control rod absorbers remaining

Table 1. Comparison of the principal thermal performance parameters for Sir and other selected PWRs

Plant parameter	*Oconee (B&W)*	*Calvert Cliffs (CE)*	*H.B. Robinson (W)*	*SIR (CE/RR&A)*
Rated core power (MWth)	2568	2700	2300	1000
Number of core fuel assemblies	177	217	157	65
RCS fluid volume (m^3)	342	314	257	402
Pressuriser volume (m^3)	42·5	42·5	36·8	80
Effective PORV area (m^2)	$6{\cdot}05\times10^{-4}$	$1{\cdot}40\times10^{-3}$	$1{\cdot}97\times10^{-3}$	$8{\cdot}9\times10^{-3}$
Ratio of RCS volume to core power (m^3/MWth)	0·133	0·116	0·112	0·402
Ratio of pressuriser volume to core power (m^3/MWth)	0·017	0·016	0·016	0·080

inserted into each fuel element. This ensures sufficient shutdown margin without the necessity to use dissolved boric acid.

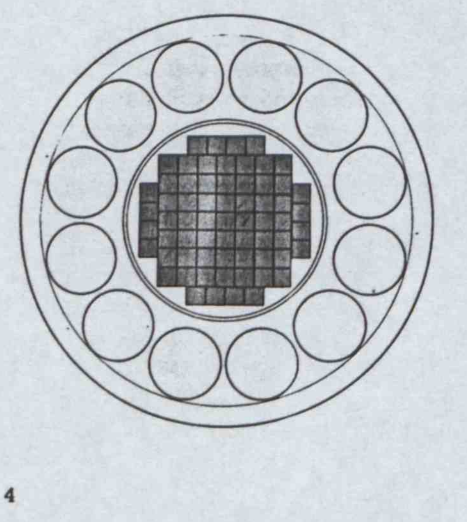
The core is designed to have a negative moderator temperature coefficient which is always sufficiently large to give stable reactor operation and to enhance the safety of the system response over a range of transient and accident conditions.

Steam generators

There are 12 identical steam generators in the Sir. They are of a once through design arranged in an annular space in the pressure vessel above the core. Figure 3 shows their position within the vessel. A cross section through the vessel at the level of the steam generators is shown in figure 5.

This arrangement enables the reactor to be refuelled without the need to disturb the steam generators and steam generator replacement can be performed with the core installed. The steam generator tubes are straight, with flat tubesheet headers top and bottom. The steam penetrations are level with the top steam header; feed penetrations are a little lower, with internal pipes taking feedwater down to the bottom feed header. Secondary water circulates inside the tubes, so there are no crevices exposed to secondary chemicals. Furthermore, and in contrast to conventional designs, the tube welds are in compression and hence any defects should not enlarge into cracks.

Figure 5. Cross section through the RPV showing the position of the steam generators



The steam generators are constructed from inconel 690 to minimise corrosion and can be isolated individually, enabling the plant to be operated at high power even if a defective unit is isolated. Figures 6 and 7 illustrate the straight tube, flowpath characteristics and the flows and layout in the upper header region respectively.

Pressuriser

Figure 3 shows the position of the pressuriser in the upper head of the RPV. Figure 8 gives more detail on its layout and operation.

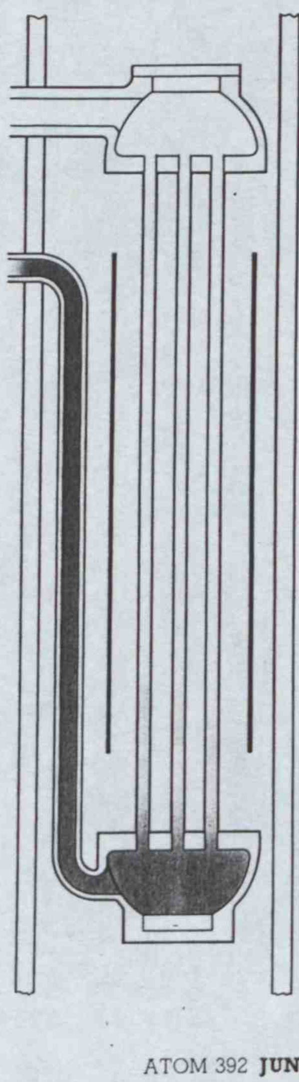
The pressuriser maintains primary circuit pressure by heating (or cooling) a steam bubble at the top of the upper head. Unlike standard designs there are no external spray lines or surge lines. Spray and surge behaviour is induced entirely by primary circuit volume changes and is therefore entirely passive. Pressuriser and primary circuit volumes are interconnected by vortex diodes in the lower dividing membrane to ensure that inflow comes through spray nozzles into the steam region and outflow is from the water region.

The normal water level will be such as to give 40 m^3 of space for both heated water and the steam bubble. This is very much larger (in terms of specific volume/power ratio) than standard designs and comparative figures are again given in table 1.

Reactor coolant pumps

The pumps are of the sealed (ie glandless) type with added inertia to increase pump rundown time. With the primary water level lowered, they can be removed radially for servicing or replacement without having to remove the vessel closure head. Space is provided for this operation within the header gallery portion of the below ground level primary containment. In order to allow for continued removal of decay heat through the steam generators by natural circulation of the primary water with a lowered water level, vortex diodes are

Figure 6. Flow pathways in the steam generator



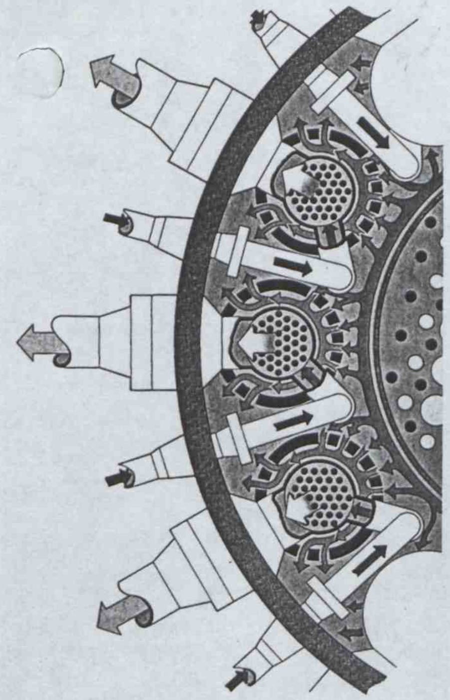


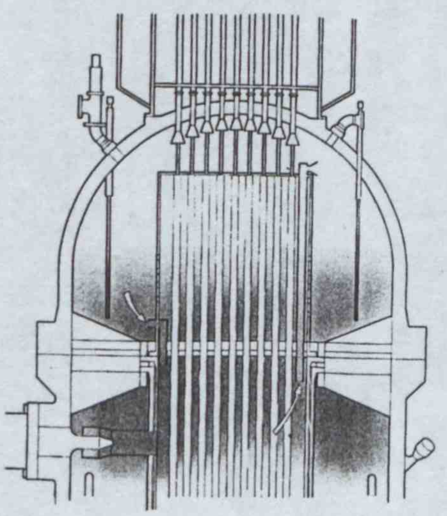
Figure 7. Flow pathways in the steam generator upper head region

provided in the chimney wall below pump level which permits pump bypass flowpaths.

With a 50 Hz supply, the pump speed is 1750 rev/min with a maximum power of 1100 kW/pump. Figure 9 gives a detailed schematic view of the flowpath and mounting arrangements for the pumps.

The steam produced in the steam generators is used to drive the turbogenerator in just the same way as in standard plant. There are some differences associated with the once through design (eg the need for crud control and the superheat capability of the steam generators) but these are not significant features. For completeness,

Figure 8. The integral pressuriser arrangement



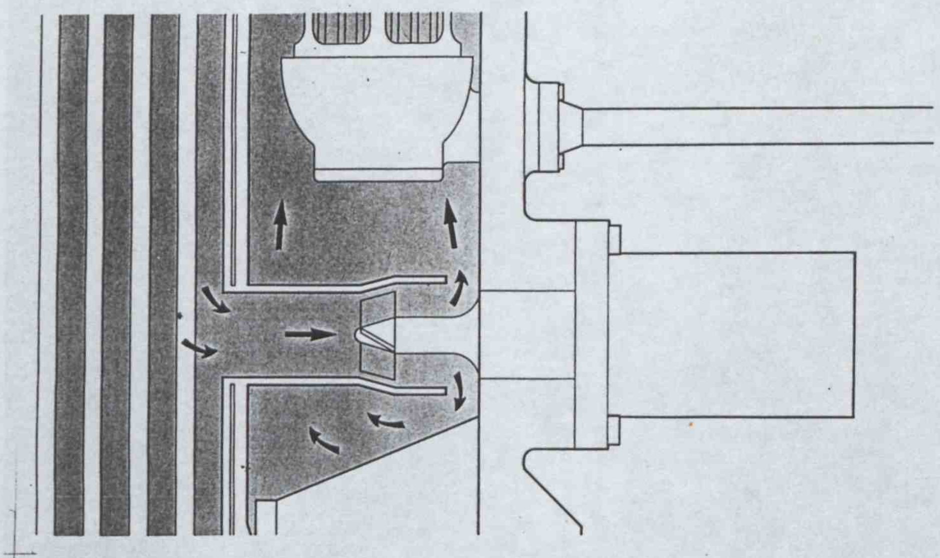


Figure 9. Flow pathway and mounting arrangements for the pumps

the secondary steam circuit is shown in figure 10.

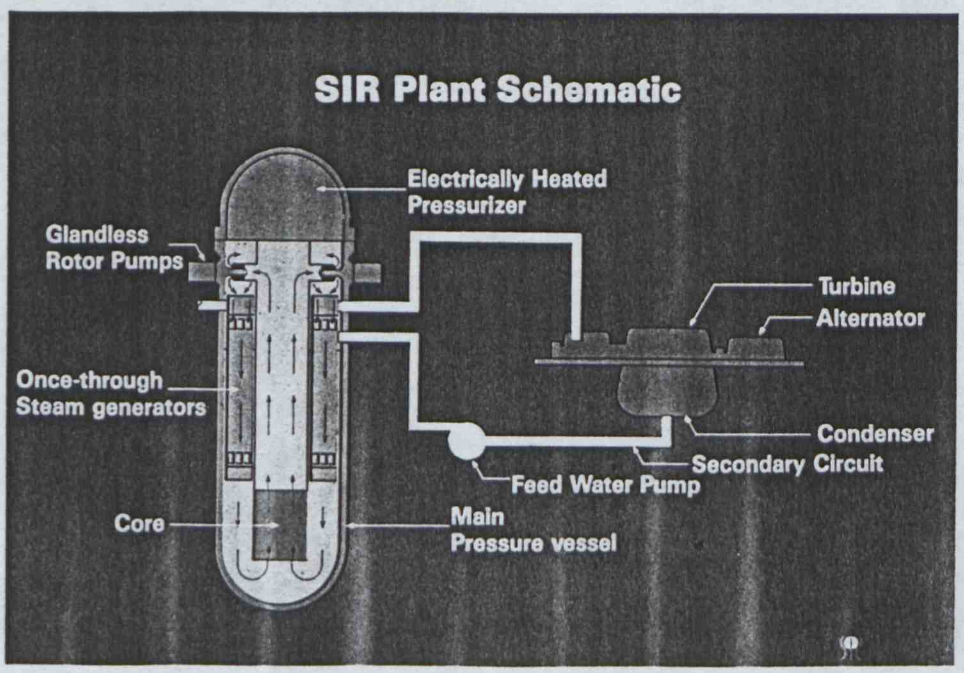
Safety features and systems

One of the principal advantages of the Sir design lies in the robustness of the core and primary circuit to fluctuations in both power and flow. Table 1 shows that for all of the important core and thermal performance parameters the design is superior to typical large PWRs. Thus, with a low power density core, the fuel (which is of a standard type reactor design) can sustain up to 115 per cent overpower before its operating margins are exceeded. This is coupled with a very strong negative moderator temperature coefficient and means that for all transient events the reactor is essentially self regulating within the 115 per cent margin. Furthermore, undercooling transients are mitigated by the low coolant inventory on the secondary side and the negative power coefficient. We believe there are *no* transient events which threaten the core and hence no diverse emergency shutdown system should be necessary.

All reactors require systems to remove decay heat and to provide an emergency source of coolant. Sir is no different in this respect but, because the demands on these systems are much reduced, their needs can be satisfied more simply. Figure 11 shows in outline the basic safety systems on the reactor.

- *Emergency core cooling system (ECCS)*. Elimination of all large primary circuit pipework outside the vessel has been discussed earlier. From the safety systems point of view this has very important ramifications. The largest pipebreak in the primary circuit is 70 mm diameter. (This is the pipe supplying the chemical volume and control system.) Thus there is no possibility of rapid

Figure 10. The secondary side steam circuit



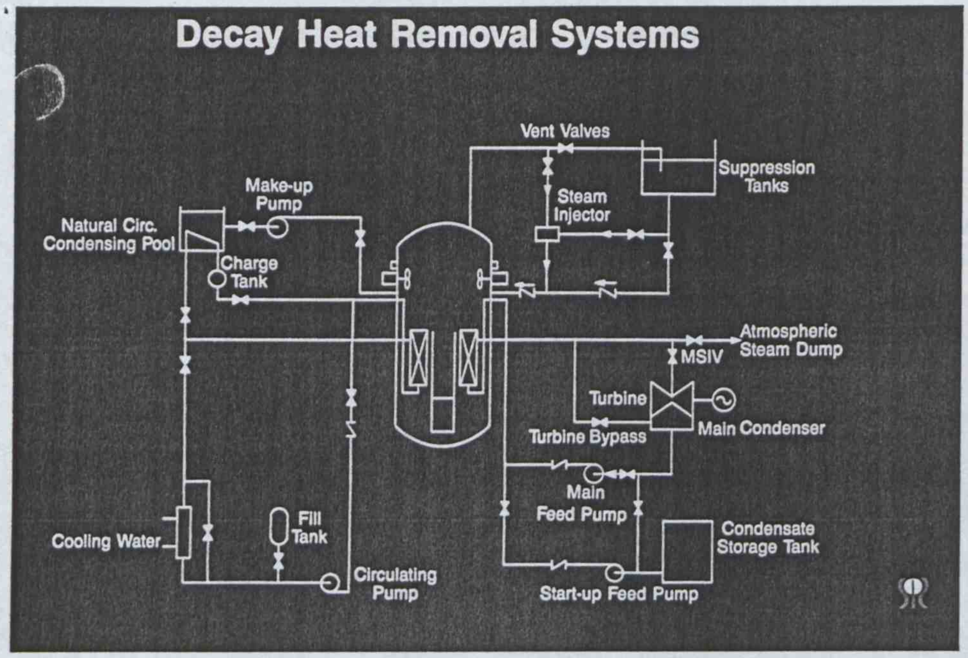


Figure 11. Circuit diagram showing decay heat and emergency injection systems

emptying of the main vessel requiring massive and early injection of ECCS water. Furthermore, the *lowest* penetration of the vessel is 8·9 m *above* the core. Hence there remains a large head of water to cover the core. Additionally, loss of steam through such a break is a far more efficient way of removing energy than by losing solid water. All of this leads to a much reduced requirement for emergency core cooling. There is no requirement for a low head high volume system and high pressure injection can be provided for by a completely passive steam injector which uses primary side steam and obtains its water supply from the containment pressure suppression pools. These are above the vessel and so, if the system is depressurised, coolant flow can be guaranteed by gravity drain. Therefore we have an emergency coolant injection system which is simple, completely passive and of low capacity requirement.

• *Decay heat removal.* Figure 11 also shows the principal connections for the decay heat removal circuits. Normally, when cooling down for maintenance and refuelling, the steam generators with turbine bypass are used and heat is rejected through the condensers. This is shown by the magenta circuit in figure 11. This can be achieved by natural circulation on the primary side but requires feed pumps and other equipment on the secondary side. If the temperature and steam pressure are too low for this mode of cooling, then heat is removed using water circulated and cooled by the component cooling water system. Should there be no ac power available, heat is removed by a closed cycle, natural convection, boiling and condensing system which only requires battery power to operate the initiation valves. The heat sink for the system is sized to provide a minimum of 72 hours' heat removal without operator intervention. Decay heat removal is also available without using the steam generators at all. This uses the safety relief valve lines and containment pressure suppression tanks.

In summary, we can say that decay heat removal is provided for by active, active/passive and totally passive systems which are both redundant and diverse. In this, the decay removal systems show the features we would expect to have on a next generation plant.

Containment and its safety systems

The possibility that one of the large primary coolant pipes in a standard PWR design might fracture has determined their requirements for containment. If an instantaneous fracture of the 30" dia main coolant pipes was to occur, then the contents of the primary circuit would rapidly be blown down, and this calls for a large strong building to contain it. The so called large dry containment is typical of standard PWR plant.

For Sir, we have no equivalent to the large break and can take a different route to containment design. In many ways the integral nature of Sir gives it features more akin to the direct cycle boiling water reactors in terms of its containment requirements. The maximum pipebreak is small, hence the rate of pressurisation is small. Energy can be removed using a simple pressure suppression concept in which steam is condensed in a large pool of water. In order to take full advantage of the small size of Sir the pressure suppression system is contained in steel tanks. There are eight of them and their positions are shown in the 3D cutaway drawing in figure 12. This system has a number of advantages:

• using steel tanks and enhancing the surface to volume ratio by having eight of them means that heat can be rejected via natural circulation. The principles of the flowpaths are shown in figure 13. This allows for 72 hours of heat removal with no need for operator intervention;

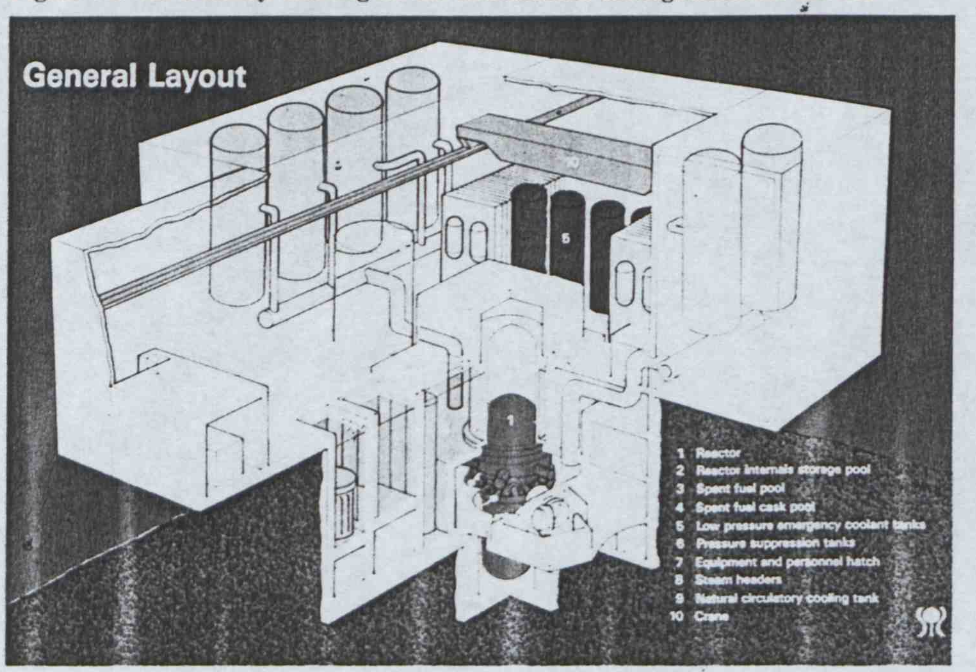
• the pressure suppression pools act as scrubbers for any fission products which may be in the steam, thus providing an effective filter;

• steel tanks can be guaranteed to be leak tight much more easily than lined concrete structures with many penetrations;

• the steel tanks are sized for transportability, hence adding to the overall constructibility of the plant.

A summary of all the technical data for the plant is given in table 2.

Figure 12. 3D cutaway drawing of the containment arrangements for the Sir



Costs

It is quite clear that no matter how appealing technically the Sir design might be, it will not get built unless it is an economic proposition. There is no doubt that this is the most contentious and commercially sensitive issue relating to any new design.

The costs of any electricity generating plant can be broken down into three main parts: its capital costs; fuel; and the interest charges, particularly interest during construction (IDC).

For all nuclear plant it is capital and IDC which dominate fuel costs. In the Sir design no one item can be identified as being the dominant reason why its costs are competitive with larger plant. However, it is very important to bear in mind that Sir approaches the PWR concept from a completely new arrangement of components and hence we are not simply scaling down one of the traditional designs. What happens when we scale up Sir is discussed later.

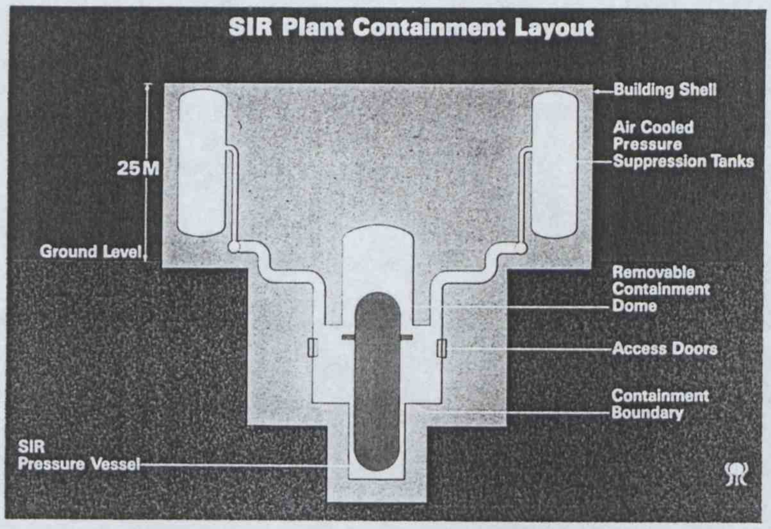


Figure 13. Natural circulation cooling of the containment pressure suppression tanks

Cost savings for Sir are achieved by:

- *Modularisation.* All the principal components – RPV, steam generators, pumps etc – come in modules and are simply plugged in on site. There is a very much reduced on-site requirement for nuclear grade welding etc;
- *Factory fabrication.* All Sir primary circuit components are built in a factory where full quality control and production line techniques can be used. Even a significant fraction of the containment structure will be built in this way;
- *Speed of construction on site.* Only the reactor cavity and pressure suppression part of containment is nuclear grade the remaining plant is the same as in any power station. By timing the delivery of major components to the site, we will achieve a construction schedule of 36 months. Not only does this reduce the IDC, it also offers a rapid revenue stream for potential investors.

All these features contribute to cost savings and we calculate that a series-ordered Sir power station would be very competitive with the larger units currently being built.

Flexibility

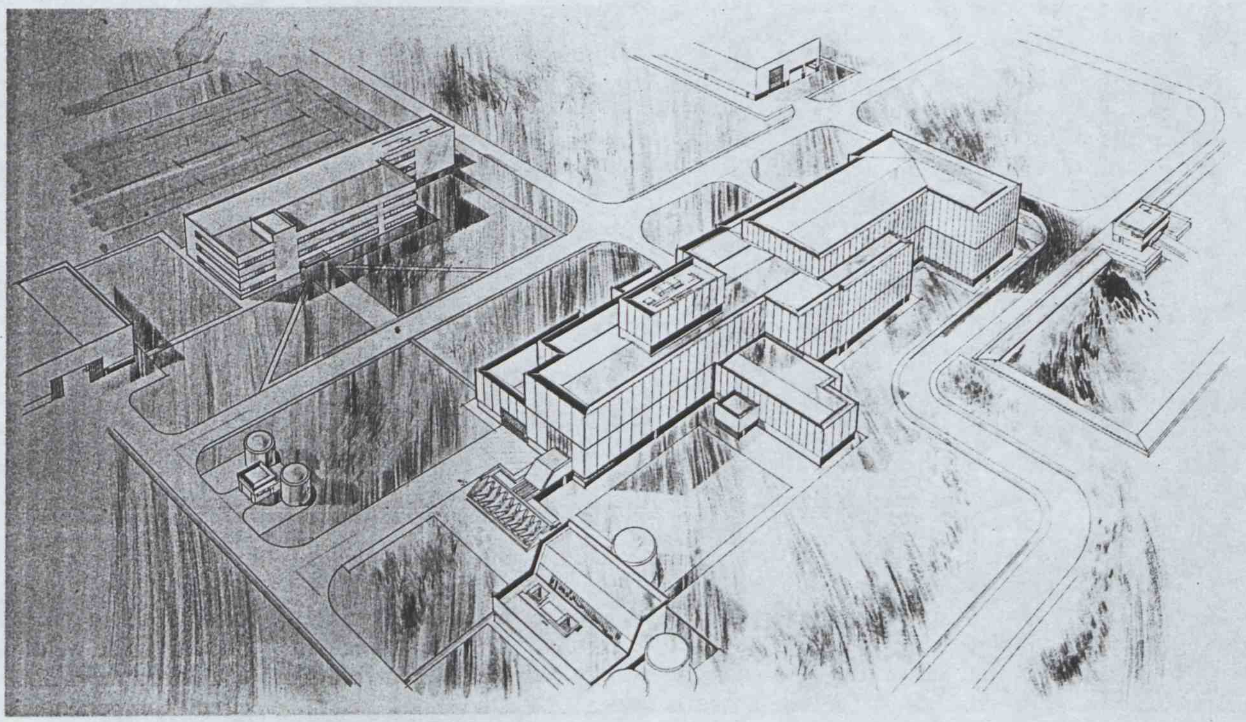
The layout of a single reactor Sir power station is shown in figure 12. This has been the basis of our cost calculations and siting requirements in the UK. However, we believe that the market in the USA will be more favourably inclined to 600 MWe or so as the standard plant capacity. A design has therefore been produced for a twin unit plant two reactors driving a single turbine. This offers a number of advantageous features, not least considerable cost savings.

Having decided on a quantum of generating capacity of 300 MWe, we can now claim economies of scale on that basic unit. Thus, while the single unit plant has achieved its economic targets by using innovative design, we can go forward from there with even more favourable designs. Figure 14 gives an impression of what a four-unit (1200 MWe) plant might look like. Of course, any size which is a multiple of 300 MWe can be provided.

Table 2. Basic parameters for the Sir system

Plant data	
Design lifetime	60 years
Power output (design)	320 MWe
Reactor power	1000 MWth
Reactor type	Pressurised water reactor (PWR)
Plant style	Integral primary circuit
Primary circuit	
Design pressure	19·4 MPa (194 bar)
Operating pressure	15·5 MPa (155 bar)
Coolant flow	7500 kg/s (7·38 t/s)
Core inlet temperature	295°C (563°F)
Core outlet temperature	318°C (604°F)
Reactor core	
Moderator	Light water
Fuel	Low enriched UO_2
Fuel enrichment	3·3 – 4·0 per cent
Reactivity control	Fuel loading, burnable poison, control element assemblies, no soluble boron
Clad material	Zircaloy–4
Power density	55 kW/litre
Minimum DNBR	2·6
Refuel cycle	24 months
Steam generators (SGs)	
Number	12
Type	Modular once through
Steam temperature	298°C (568°F)
Steam pressure	5·5 MPa (55 bar)
Superheat	28°C (82·4°F)
Feedwater temperature	224°C (435°F)
Feedwater flow	516 kg/s (1138 lb/s)
Tube bundle length	8·5 m (27 ft 10 in)
Heat transfer area	11 140 m² (13 323 sq.yards)
Material	Inconel 690
Pressuriser	
Type	Integral with reactor vessel (in head)
Volume	80 m³ (2825 ft³)
Reactor coolant pumps	
Number	6
Type	Glandless, wet winding
Power (design)	1100 kW
Operating power	700 kW
Instrumentation and control	
Control complex	Based on CE nuplex 80+™
Containment	
Type	Passive, pressure suppression
Safety systems	
Decay heat removal	Passive, through SGs using natural convection boiling/condensing cycle
Emergency cooling injection	Passive, steam injectors powered by pressuriser steam
Construction schedule	
Site work to first concrete	6 months
First concrete to commercial operation	30 months
Order to commercial operation	54 months

Figure 14. Layout for a potential four unit 1200 MWe Sir power station



Licensability and public acceptability

One of the principal aims of the Sir project is to provide a design which clearly tackles those areas which have caused concern particularly in the public domain. We cannot say whether this design will be accepted, although the press coverage so far has been very favourable. However, there are features of this design which we believe still address public concerns. These include:

- very much reduced dependence on operators in responding to out of normal conditions;
- the use of large thermal inertia to damp down the response time of the reactor;
- a smaller plant which can be located on sites with very little environmental impact;
- less disruption of local communities during construction;
- a plant that is easier to decommission at the end of its life.

Such qualitative statements as these have to be presented in a much more quantitative and formal way to the licensing authorities. As yet we have not submitted the Sir design to either the UK Nuclear Installations Inspectorate (NII) or the US Nuclear Regulatory Commission (USNRC). We cannot do this until there is sufficient information on the plant and the potential site for them to make a professional judgement. However, we have used design targets which, we believe, will lead to a licensable design.

The requirements are slightly different in the USA and the UK, but generally speaking the principles to be followed for advanced designs are convergent, rather than divergent. However, in neither country are there design criteria for advanced reactors which we can adopt and guarantee licensability.

There are activities in this area. For example, the Electric Power Research Institute in the USA is producing a massive guidelines document for next generation plant. This will be most useful in giving a yardstick against which to judge Sir. At the end of the day, though, it will be regulators who will have to decide if what Sir offers lives up to their expectations.

At the end of the day, . . . it will be regulators who will have to decide if what Sir offers lives up to their expectations.

Prospects for the future

We have two parallel and integrated activities. The first is to develop a design capable of generic licensing in the USA. The USNRC is introducing a licensing method whereby a design can be given the official stamp of approval in a general way, and then only local site specific matters need to be considered for each plant project. In this way, it is hoped that the current bottleneck in US licensing will be broken. The goal is a design certified by the mid 1990s.

In the UK we hope to be able to press forward faster with a plant construction project with the backing of parts of the ESI and the UK nuclear industry. The Atomic Energy Authority has proposed the Winfrith site as a location for unit 1, as the site's infrastructure is already available to cope with a plant of this size.

Furthermore, it is in a geographical region where electricity demand is high (around Bournemouth/Poole) and the power is needed in the area.

Summary

In attempting to design a new reactor, the four partners set themselves three principal goals:

- it must be economic;
- it must use existing technology;
- it must have the safety features expected of an advanced plant.

We believe we have met the first criterion by innovative design, use of modern manufacturing techniques and speed of construction. Multiple unit plants show significant economies of scale, but baselined to a single 300 MWe unit which is itself economic when compared to present designs.

The design relies entirely on components, materials, control systems and fabrication techniques which are well established and proven. What is new is that they have all been brought together in this way for the first time. There is no requirement for a prototype reactor, or for a long development programme.

The safety features of the plant reflect the lessons learned in recent years from accidents and near accidents and from the intensive technical and public debates which they have spawned. We believe we have covered all the necessary aspects of safety but this is an area where we will continue to refine and update the design.

Acknowledgement

The author wishes to thank Dr Ian Gibson of AEE Winfrith, Dr Steven Hall of SRD and Dr John Caisley of Harwell for their assistance in writing this article. He gratefully acknowledges the assistance of Rolls-Royce and Associates in the preparation of photographs. ■

Env Affairs
Acid Rain
Pt 11

R F.

c- Mr Barrows

CABINET OFFICE

70 Whitehall London SW1A 2AS

01-270 0101

From the Secretary of the Cabinet and Head of the Home Civil Service

Sir Robin Butler KCB CVO

Ref. A089/1841

7 July 1989

Dear Geoffrey,

Thank you for your letter of 26 May about your search for a Director General for the British Committee of the World Environmental Conference.

Having made some enquiries I can suggest three people who have expressed an interest in the post. In alphabetical order they are:-

<u>David A EVEREST</u> (62) who retired in 1986 as Chief Scientist, Environmental Protection Group and Director of Science Research Policy in the Department of the Environment.

Home Address: Talland, Chorleywood Road, Chorleywood, Herts WD3 4SR. (Telephone 0923 773253).

<u>John PALMER</u> (60) who has just retired as a Deputy Secretary in the Department of Transport. His earlier career was in the Department of the Environment and its predecessor the Ministry of Housing and Local Government.

Home Address: 2 The Hermitage, Richmond, Surrey TW10 6SH. (Telephone 01 940 6536).

<u>(William) John WILBERFORCE</u> (59) retired in July 1988 as High Commissioner in Cyprus after a Diplomatic Service career.

Home Address: Markington Hall, Harrogate, N.Yorks. (Telephone Ripon 87356).

/All three have been

All three have been told that their names are being passed to you and that you will get in touch with them. Extracts from Who's Who are attached.

John Palmer has recently returned from Moscow where he was attending an international conference of the International Railways Congress Association of which he is a Vice President.

If you need any further advice you may care to have a word with Dr John Hemming, Director and Secretary of the Royal Geographical Society. I understand that he would be happy to discuss with you possible candidates in the environmental field. His office telephone numbers are 01-589 0648 and 01-637 2400.

I hope that this is helpful.

Yours ever,

Robin

WHO'S WHO EXTRACT 1989

EVEREST, David Anthony, PhD; FRSC; Visiting Research Fellow, University of East Anglia, since 1986; Research Associate, UK Centre for Economic and Environmental Development, since 1987; *b* 18 Sept. 1926; *s* of George Charles and Ada Bertha Everest; *m* 1956, Audrey Pauline (*née* Sheldrick); three *s*. *Educ:* John Lyon Sch., Harrow; University Coll. London (BSc, PhD). Lecturer in Chemistry, Battersea Polytechnic, 1949–56; Sen. Scientific Officer, 1956–58, PSO, 1958–64, National Chemical Laboratory; SPSO, 1964–70, Dep. Chief Scientific Officer, 1970–77, National Physical Laboratory; DCSO, RTP Div., Dept of Industry, 1977–79; Chief Scientist, Environmental Protection Gp, 1979–86, and Dir of Sci. Res. Policy, 1983–86, DoE. *Publications:* Chemistry of Beryllium, 1962; section on Beryllium in Comprehensive Inorganic Chemistry, 1972; papers in Inorganic Chemistry, Extractive Metallurgy and Material Science. *Recreations:* astronomy, reading, walking. *Address:* Talland, Chorleywood Road, Chorleywood, Herts WD3 4ER. *T:* Rickmansworth 773253.

PALMER, John, CB 1986; a Deputy Secretary, Department of Transport, 1982–88; *b* 13 Nov. 1928; 2nd *s* of late William Nathaniel Palmer and Grace Dorothy May Palmer (*née* Procter); *m* 1958, Lyliane Marthe Jeanjean, *o d* of René Jeanjean and Jeanne Jeanjean (*née* Larrouy); two *d*. *Educ:* Heath Grammar Sch., Halifax; The Queen's Coll., Oxford (Lit. Hum.) (MA). Entered Min. of Housing and Local Govt, 1952; Cabinet Office, 1963–65; Asst Sec., 1965; Under Secretary: DoE, 1971; Dept of Transport, 1976–82. *Club:* United Oxford & Cambridge University.

WILBERFORCE, William John Antony, CMG 1981; HM Diplomatic Service, retired; *b* 3 Jan. 1930; *s* of late Lt-Col W. B. Wilberforce and Cecilia (*née* Dormer); *m* 1953, Laura Lyon, *d* of late Howard Sykes, Englewood, NJ; one *s* two *d*. *Educ:* Ampleforth; Christ Church, Oxford. Army National Service, 2nd Lieut KOYLI, 1948–49. HM Foreign Service, 1953; served: Oslo, 1955–57; Berlin, 1957–59; Ankara, 1962–64; Abidjan, 1964–67; Asst Head of UN (Econ. and Social) Dept, 1967–70, and of Southern European Dept, 1970–72; Counsellor, 1972–74, and Head of Chancery, 1974–75, Washington; Hd of Defence Dept, FCO, 1975–78; Asst Under-Sec., RCDS, 1979; Leader of UK Deleg. to Madrid Conf. on Security and Cooperation in Europe Review Meeting, with rank of Ambassador, 1980–82; High Comr in Cyprus, 1982–88. Hon. DHum Wilberforce, 1973. *Recreations:* the turf, travel, gardening. *Address:* Markington Hall, Harrogate, N Yorks. *T:* Ripon 87356. *Club:* Athenæum.

CC PC

SECRETARY OF STATE FOR THE ENVIRONMENT

2 MARSHAM STREET
LONDON SW1P 3EB
01-276 3000

My ref:

Your ref:

CONFIDENTIAL

Charles Powell Esq
Private Secretary
10 Downing Street
LONDON SW1A 2AA

CDP 4/7.

4 July 1989

Dear Charles

Thank you for your letter of 13 June to Roger Bright enclosing a copy of a message from President Bush to the Prime Minister about clean air policies in the United States.

We have learned that - apart from telephoning Prime Minister Mulroney - the President has written only to Mrs Thatcher and to President Mitterand, the latter presumably in his capacity as President of the Council of Ministers.

We are sure that the Prime Minister will wish to respond warmly to this message from the President. We are putting together some notes and a draft reply which we hope to let you have in the next few days.

Yours

CEJBush

KATE BUSH
Private Secretary

ENV AFFAIRS: Acid Rain Pt 11

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10 DOWNING STREET

LONDON SW1A 2AA

From the Private Secretary

3 July 1989

Dear Roger.

GLOBAL ENVIRONMENT: ECONOMIC ISSUES

Thank you for your letter of 30 June, covering a paper for the Prime Minister on the economic aspects of international environmental issues. The Prime Minister thought it was a good paper, although with a bit too much jargon in places. She suggests one or two amendments as follows:

- paragraph 3.2, fifth and sixth sentences to read: "In these circumstances, it is better to anticipate the risk with corrective policies: the Montreal Protocol designed to phase out the use of CFCs is a case in point. However, to the extent that environmental damage has already arisen, there may be no alternative to policies which adapt to the new situation: the response to sea level rise is a striking example."

- subheading to paragraph 3.4 to read: "Future Generations".

- paragraph 4.4 last sentence for "preserve a level playing field" substitute "provide a fair basis".

I should be grateful if a revised version could be produced with these changes. I do not think that the Prime Minister has any specific use in mind for the paper: it will serve as a very useful quarry for arguments.

I am copying this letter to Alex Allan (H.M. Treasury), Stephen Wall (Foreign and Commonwealth Office), Neil Thornton (Department of Trade and Industry), Myles Wickstead (Overseas Development Administration), Stephen Haddrill (Department of Energy), Roy Griffins (Department of Transport), Shirley Stagg (Ministry of Agriculture, Fisheries and Food), Trevor Woolley (Cabinet Office) and Nigel Wicks (H.M. Treasury).

Yours sincerely,

Charles Powell

C. D. POWELL

Roger Bright, Esq.,
Department of the Environment.

CC PC
RM

CONFIDENTIAL

SECRETARY OF STATE FOR THE ENVIRONMENT

2 MARSHAM STREET
LONDON SW1P 3EB
01-276 3000

My ref:

Your ref:

Prime Minister

There's rather a lot of jargon. I wonder if the G7 will all understand it. Otherwise it's good.

CDP 30/6.

I have done 2 or 3 corrections where I thought the jargon was unhelpful.

Charles Powell Esq
Private Secretary to
The Prime Minister
10 Downing Street
LONDON
SW1A 2AA

30 June 1989

Dear Charles

GLOBAL ENVIRONMENT: ECONOMIC ISSUES
PAPER FOR THE PRIME MINISTER

At her meeting on global climate on 19 April the Prime Minister called for 'further work on the economic aspects of international environmental issues to help prepare a well researched UK paper in good time for the Economic Summit' in July. The Department of the Environment with ODA were put in the lead, with support from other Departments.

I attach a paper that has been drafted by officials, on this basis. My Secretary of State and the Minister for Overseas Development have seen it and are content for it to be sent forward.

Copies of this letter and attachment go to Alex Allen (Treasury), Stephen Wall (FCO), Neil Thornton (DTI), Myles Wickstead (ODA), Stephen Haddrill (DEn), Roy Griffins (DTp), Shirley Stagg (MAFF), Trevor Wooley (Sir Robin Butler's office) and to Nigel Wicks at the Treasury.

Yours sincerely

Roger Bright

R BRIGHT
Private Secretary