Declaration

I declare that this thesis has been composed by myself and is my own work

John R. Walker
1 July, 1986.
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ABSTRACT

British attitudes to proliferation cannot really be understood without reference to the historical, strategic and economic background of Britain's own nuclear programmes. The experiences and lessons learned during the civil and military programmes in the 1950s and 1960s played a crucial role in shaping British perceptions of, and attitudes to, the proliferation issue. The relationship between civil and military technology is important here because nuclear energy cannot be used as a source of power without simultaneous production of material suitable for use in a bomb. Two issues are relevant here; first, the actual relationship between the British civil and military programmes; second, British conception of the long-term proliferation implications of these relationships.

Successive British governments have regarded possession of nuclear weapons as fundamental to British national security, but they have also sought to prevent their spread to other states. However, in the British case American policies between 1946 and 1953, and subsequently, were instrumental in encouraging independent nuclear programmes. These sought to maintain the US monopoly over nuclear materials and technology by making it illegal for the US to provide either to other countries including Britain. However, this only encouraged proliferation. US unreliability and policies based on denial appear to have persuaded successive British governments of the value of a stable and predictable international non-proliferation regime. Consequently it was considered important to maintain stability and predictability in international nuclear trade through assurance of supplies of nuclear materials, equipment and information subject to legitimate security considerations. This, it was thought, would reduce states' incentives to build indigenous sensitive fuel cycle facilities, and reduce hostility to the non-proliferation regime.
British nuclear policies have remained basically unchanged, and have been instrumental in moulding British attitudes to proliferation.

In the 1950s the perceived unreliability of the coal industry posed a threat to British energy security. This was the context in which the first nuclear power programme was launched. Nuclear power was thought to have potential benefits for energy security since it could provide reliable and predictable energy supplies.

Reactor and fuel exports have always been a major objective of British nuclear policy notwithstanding the potential proliferation implications. British governments have never opposed the principle of nuclear exports on non-proliferation grounds; on the contrary, British non-proliferation policies have sought to defend UK commercial interests. During the 1960s commercial objectives became integrated with non-proliferation policy: there is no contradiction between commercial objectives and security requirements. They are mutually reinforcing.

It is necessary to examine the British civil-military relationship; programme rationales and objectives; nuclear export policy and the military programme, before seeing how these have influenced British attitudes to, and policies on, proliferation. Part 2 examines the relationship between these factors and the British role in the Non-Proliferation Treaty negotiations and its 1975 and 1980 Review Conferences; the IAEA and Euratom safeguards systems; the International Nuclear Fuel Cycle Evaluation; the Nuclear Suppliers' Group; Multinational/Regional Fuel Cycle Centres; International Plutonium Storage and the Committee on the Assurance of Supply.
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The views expressed here are my own and do not derive from my present position as a Senior Research Officer in the Arms Control and Disarmament Research Unit, Foreign and Commonwealth Office, nor do they reflect the views of the FCO or HMG. The information used in this thesis has been derived exclusively from sources in the public domain, and not from official information.

I would also like to thank the Librarian and staff of the SSEB Library in Glasgow for allowing me to consult their collection of nuclear journals and IAEA publications; and to Margaret Marshall for typing my illegible manuscripts.

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John R. Walker
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GLOSSARY

ABM: Anti-Ballistic Missile
ACSA (N): Assistant Chief Scientific Advisor (Nuclear)
AED: Atomic Energy Division
AEE: Atomic Energy Establishment
AE(O)C: Atomic Energy (Official) Committee
AERE: Atomic Energy Research Establishment
AGR: Advanced gas cooled reactor
ANF: Atlantic Nuclear Force
APC: Atomic Power Constructions
ASM: Air-to-Surface Missile
AWRE: Atomic Weapons Research Establishment
Back-end of the cycle: "The part of the fuel cycle following the removal of spent fuel elements from the reactor" (1.)
BEA: British Electricity Authority
BNDC: British Nuclear Designs and Constructions
BNF: British Nuclear Forum
BNFL: British Nuclear Fuels Limited
BNX: British Nuclear Export Executive
Burn-up: "A measure of reactor fuel consumption. It is expressed as the amount of energy produced per unit weight of fuel in the reactor." (1)
BWR: Boiling Water Reactor
CANDU: Canadian deuterium uranium reactor
CAS: Committee on Assurances of Supply
CCD: Conference of the Committee on Disarmament
CD: Committee on Disarmament
CEA: Commissariat 'a 1' Engerie Atomique
CEGB: Central Electricity Generating Board
CENTEC: Gesellschaft fur Centrifugentechnik mbh
centrifuge method of enrichment: "An enrichment process in which lighter isotopes are separated from heavier ones by means of ultra-high-speed centrifuges." (1)
CFR: Commercial Fast Reactor
CNEA: Comision Nacional de Energie Atomica
COCOM: Coordinating Committee for Multilateral Export Controls
COGEMA: Compagnie Generale des Matieres Nuclaires
coolant: "A substance circulated through a nuclear reactor to remove or transfer heat. Common coolants are light or heavy water, carbon dioxide and liquid sodium" (1)
core: "The central portion of a nuclear reactor containing the fuel elements and usually the moderator, but not the reflector." (1)
CPRS: Central Policy Review Staff
CRO: Commonwealth Relations Office
CTB: Comprehensive Test Ban
denaturing: "The mixing of a fissile nuclide with an isotopic non-fissile nuclide so as to render the former unsuitable for nuclear weapons." (1)
DEN: Department of Energy
DFR: Dounreay Fast Reactor
DOE: Department of Energy (US)
DTI: Department of Trade and Industry
ENDC: Eighteen Nation Disarmament Committee
ENEA: European Nuclear Energy Agency
enrichment: "A process by which the relative abundance of the isotopes of a given element are altered, thus producing a form of the element enriched in one particular isotope." (1)
ERDA: Energy Research and Development Agency
EURATOM: European Atomic Energy Community
EURODIF: European Gaseous Diffusion Uranium Enrichment Consortium
FBR: Fast Breeder Reactor
FCO: Foreign and Commonwealth Office
fissile material: "A material fissionable by neutrons; of all energies, especial thermal neutrons: for example, uranium-235 and plutonium -239." (1)
fuel cycle: "the series of steps involved in preparation and disposal of fuel for nuclear power reactors. It includes mining, refining the ore, fabrication of fuel elements, their use in a reactor, chemical processing to recover the fissile material remaining in the spent fuel, re-enrichment of the fuel material, and
refabrication into new fuel elements." (1)

fuel element: "A rod, tube, plate, or other mechanical shape or form into which nuclear fuel is fabricated for use in a reactor." (1)

fuel fabrication: "The manufacture of fuel elements for use in reactors." (1)

FSS: Full scope safeguards

gaseous diffusion: "A method of isotope separation based on the fact that gas atoms or molecules with different masses will diffuse through a porous barrier (or membrane) at different rates. The method is used to separate uranium -235 from uranium - 238." (1)

GEC: General Electric Company (UK)

HEU: Highly Enriched Uranium

horizontal proliferation: "The spread of nuclear weapon capabilities to non-nuclear weapon states." (1)

HSP: Hexapartite Safeguards Project

HTR: High Temperature Reactor

IAEA: International Atomic Energy Agency

INFCE: International Nuclear Fuel Cycle Evaluation

IPS: International Plutonium Storage

irradiated fuel: "Nuclear fuel after it has been placed in a reactor." (1)

isotopes: "Nuclides of the same chemical element but different atomic weight, that is with the same number of protons but different numbers of neutrons." (1)

JCAEA: Joint Committee on Atomic Energy

LDC: Lesser Developing country

LEU: Low Enriched Uranium

LMFBR: Liquid Metal Fast Breeder Reactor

load factor: "The ratio of energy actually produced to that which would have been produced in a given time had the reactor operated continually at the rated capacity." (1)

Magnox: "Magnesium alloy used to can the uranium in the fuel elements of the UK second generation nuclear reactors

MBA: Material Balance Area
MBFR: Mutual Balanced Force Reductions
MFCC: Multinational Fuel Cycle Centre
MLF: Mutual Nuclear Force
Moderator: "A material, such as ordinary water, heavy-water, or graphite used in a reactor to slow down fast neutrons to thermal energies." (1)
MOD: Ministry of Defence
MOS: Ministry of Supply
MOX: Mixed Oxide Fuel
MTR: Material Testing Reactor
MWD/te: Megawatt day per tonne
MW(e): Megawatts of electricity
MW(th): Megawatts of thermal power
Natural uranium: "Uranium as found in nature, containing 0.7 per cent of U-235, 99.3 of U.238, and a trace of U.234." (1)
NIDC: Newly Industrialised Developing Country
NNA: Neutral and Non-Aligned
NNC: National Nuclear Corporation
NNWS: Non-Nuclear Weapons State
NPAB: Nuclear Power Advisory Board
NPC: Nuclear Power Consortium
NPT: Non-Proliferation Treaty
NPTRC: Non-Proliferation Treaty Review Conference
NSG: Nuclear Suppliers' Group
NWS: Nuclear Weapons State
OECD: Organisation for Economic Co-operation and Development
OECE: Organisation for European Economic Co-operation
Once-through cycle: "A nuclear fuel cycle in which the spent fuel elements are not reprocessed for the purpose of recovering the fissile materials U-235 and PU-239." (1)
PAEC: Pakistan Atomic Energy Commission
PFR: Prototype Fast Reactor
PIPPA: Pressurised Pile Producing Power and Plutonium
Plutonium: (PU) "A radioactive, man-made, metallic element with atomic number 94. Its most important isotope is fissile plutonium-239 produced by
neutron irradiation of uranium-238. It is used for reactor fuel and in weapons." (1)

PNE: Peaceful Nuclear Explosions
PSA: Polaris Sales Agreement
PWR: Pressurised Water Reactor
RECOVER: Remote Continual Verification
reprocessing: The chemical and mechanical processes by which plutonium and the unused uranium-235 are recovered from spent fuel elements." (1)

research reactor: "A reactor primarily designed to supply neutrons or other ionizing radiation for experimental purposes. It may also be used for training, materials testing and production of radionuclides." (1)

RFCC: Regional Fuel Cycle Centre
SAAEC: South African Atomic Energy Commission
SAC: Strategic Air Command
SACLANT: Supreme Allied Commander Atlantic
safeguards: set of regulations, procedures and equipment designed to deter through assurance of timely detection the diversion of nuclear materials for military purposes.
SAGSI: Standing Advisory Group on Safeguards Implementation
SALT: Strategic Arms Limitation Treaty (Talks)
SAM: Surface-to-Air Missile
SGHWR: Steam Generating Heavy Water Reactor
SLBM: Submarine Launched Ballistic Missile
SSBN: Nuclear Powered Ballistic Missile Submarine
SSEB: South of Scotland Electricity Board
SSN: Nuclear-Powered Attack Submarine
SWU: "Separative Work Unit. A measure of the work required to separate uranium isotopes in the enrichment process. It is used to describe the capacity of an enrichment plant." (1)

tails assay: The percentage of U-235 left in the depleted uranium after passing through the enrichment plant.

THORP: Thermal Oxide Reprocessing Plant
TNPG: The Nuclear Power Group
UF₆: Uranium Hexafluoride
UKAEA: United Kingdom Atomic Energy Authority
UNGA: United Nations General Assembly
UO₂: Uranium Oxide
URENCO: Uranium Enrichment Company
URG: United Reprocessors GmbH

vertical proliferation: The qualitative and quantitative expansion of capacities of forces in existing nuclear weapon states." (1)

weapons grade material: " A material with a sufficiently high concentration of the nuclides uranium-233; uranium-235 or plutonium 239 to make it suitable for a nuclear weapon." (1)

WPI: Windscale Public Enquiry

CHAPTER 1. INTRODUCTION

1. BRITISH ATTITUDES TO NUCLEAR PROLIFERATION: THE WHY AND WHEREFORS

It may be argued that the nuclear age really began for Britain in February, 1940 when the Birmingham based refugee scientists Rudolf Peierls and Otto Frisch produced their memorandum "on the Properties of a Radioactive super-bomb". As a consequence Britain became the first country to decide to build an atomic bomb. However British atomic research became part of the US Manhattan Project in late 1943. An independent British atomic weapons programme did not emerge until 1947. Margaret Gowing notes that Britain was the 'midwife of the bomb'.

British officials, scientists and politicians considered that since Britain had been intimately involved with nuclear weapons from the very beginning, this merited a pre-eminent position for Britain in post war international affairs in general and nuclear politics in particular. Nevertheless Britain was only the third state to test an atomic bomb. Since then the British have made a significant contribution to the development of civil and military uses of nuclear technology. Forty years after the Peierls/Frisch memorandum nuclear power continues to play an important part in British defence and energy policies. It is this apparently unique position which, perhaps, sets British nuclear history apart from other nuclear states.

The need to prevent the spread of nuclear weapons capability to other states was recognised by the participants in the wartime Manhattan Project. In 1943 the first non-proliferation agreement was concluded between the UK and US at Quebec. As well as outlining the nature of Anglo-American co-operation the Quebec Agreement also sought to prevent the spread of nuclear information and
technology. (3) The American 'Baruch' Plan of 1946 was perhaps the second non-proliferation proposal. Since then there have been several international attempts to constrain the spread of nuclear weapons. The almost universally accepted premiss is that the spread of nuclear weapons would pose a grave threat to international stability and security. (4) In the thirty years between 1952 and 1982 there have been several national and international attempts to confine nuclear weapons to the established nuclear powers. However, the extent and nature of the British contribution to the evolution of the international non-proliferation regime and the worldwide spread of civil nuclear power is not readily apparent. Furthermore, the factors which have moulded British perceptions of the proliferation question in general, and policies and objectives for British international nuclear policy are equally unclear.

Although there is a plethora of published material on nuclear matters in general, there are no studies which deal specifically with Britain and nuclear proliferation. It is only referred to tangentially in studies which deal either with the civil programme: Roger Williams, The Nuclear Power Decisions. British Policies 1953 - 1978; or the military programme, John Simpson, The Independent Nuclear State. The United States, Britain and the Military Atom. Margaret Gowing's official histories only cover the years 1939 - 1952. (5) For this reason this story begins in 1952. However, these and other studies of British nuclear politics and history discuss issues which are relevant to an examination of British attitudes to proliferation; for example, Lawrence Freedman makes some reference to British obligations under the Non-Proliferation Treaty in Britain and Nuclear Weapons. In Decision Making for Energy Futures. A Case Study of the Windscale Inquiry, David Pearce et al refer to the British interpretation of the NPT and UK obligations. (6) Nevertheless there is no overview of British attitudes to proliferation or how British non-
proliferation policies are shaped. The literature on nuclear matters is immense; for instance, by mid October, 1984 the Amalgamated Documents Lists of non-CEGB papers submitted to the Sizewell Public Inquiry was 267 pages long. Not all of this material is relevant. A paper presented by Ridgway Consultants entitled, "Some Similarities of Radium and Plutonium Toxity in the Beagle and Man" has no immediate bearing on a study of Britain and proliferation. Despite the enormity of the literature there are several areas where work remains to be done. In particular there are no published comprehensive studies of British nuclear export policies. Those that are available focus exclusively on reactor exports and ignore fuel cycle services.(7) Nor are there detailed examinations of the British role in the negotiation of the Non-Proliferation Treaty, and development of the IAEA safeguards system. In short, although there are numerous American studies on nuclear proliferation in general, and US policy in particular, there is no equivalent for the British experience.(8)

2. METHODOLOGICAL AND EPISTEMOLOGICAL PROBLEMS

In an area as sensitive as nuclear policy there are several practical restraints on research. These necessarily limit the scope of an examination of British nuclear policy. Perhaps the principal difficulty is the Official Secrets Act. Compared to the United States and Sweden the British government process is distinctly secretive. Until comparatively recently, for example, the blue-prints of the men's ablutions at Windscale were classified.(9) This indicates the scale of the problem. Even leading individuals in the 1945 - 1952 period knew very little about crucial decisions until they read Margaret Gowing's histories.(10) The "need to know" principle was probably at the root of this. Even though Professor Gowing has said she has had access to official papers up to 1964, she does not know which papers and files have not been released.(11)
Although the Fifty Year Rule was replaced in 1967 by a Thirty Year Rule for access to "public" documents this does not mean that all papers are released; on the contrary, many are weeded and destroyed before they reach the 30 year mark. Many are withheld under section 3(a) of the 1957 Public Records Act either for a further twenty or seventy years. Indeed files can be 'retained by the department' indefinitely. Files which are released are often incomplete with individual folios missing. Butcher notes that, "academic researchers ... have found it notoriously difficult to surmount the barriers imposed by the closed system of British civil government. The Thirty Year Rule makes comparatively little difference to students of contemporary and recent history". (12) Indeed it has been reported that many of the Suez papers have been destroyed. (13) It would appear that only a partial picture of events can be re-established and explained from the limited access to official papers in sensitive areas like defence and foreign policy. Nevertheless they may provide a "snap shot" of reality which may allow a plausible account or interpretation of past events to be made. (14)

The recollections of individuals who participated in the decision making and policy execution process are available from interviews. But as Richard Neustadt points out memory lapses are compounded by discretion. (15) Interviewees may also wish to rationalise after-the-fact; that is, explain the past with the benefit of hindsight or give a glowing account of their own role in affairs. Garthoff notes that remembrance is both selective and influenced by later perceptions. Recollection of details from events over thirty years ago, and even fifteen years, are not always one hundred percent reliable. Lord Hinton's account of one particular incident in the late 1950s was felt by some UKAEA officials to be the product of an ailing memory. (16) Nevertheless where information from interviews can be cross-checked with other responses from relevant
individuals and documentary evidence, interviews can provide a useful insight and facilitate a greater understanding of events.

One problem in an examination of British attitudes to nuclear proliferation is deciding what constitutes "British". For instance, "British" assumes a united view reflecting the interests of a monolith despite the existence of numerous bureaucracies with some responsibility for nuclear affairs. In 1982 in the UK the most important of these were the government departments: the Foreign and Commonwealth Office, the Ministry of Defence and the Department of Energy; and at a secondary level, though no less important, British Nuclear Fuels plc, United Kingdom Atomic Energy Authority, National Nuclear Corporation, Central Electricity Generating Board, South of Scotland Electricity Board. Responsibility within the Government departments is divided into smaller units. In 1984 the Nuclear Energy Department was the lead FCO department on the NPT and nuclear exports, but the Arms Control and Disarmament and Defence Departments would also be involved. In the Department of Energy the Atomic Energy Division is subdivided into four branches. Branch 2 and the Safeguards Office are responsible for non-proliferation issues. In the MOD the Assistant Chief Scientific Adviser (Nuclear), Defence Nuclear Divisions and Defence Secretariat Division 17, which dealt with arms control and disarmament matters, for example, would represent MOD interests.

Since FCO policies and statements are cleared with the MOD and given the general concern to have a united Whitehall view, it seems plausible to talk about a "British view". In his study of British nuclear power decisions Roger Williams for example, treats the UKAEA as a monolith even though he recognises that it was by no means a united organisation. The Authority was divided into five functional units; for example, Production, Engineering and
the AWRE. In particular, interest groups emerged with the various reactor designs, AGR, HTR, SGHWR and FBR. Each team was convinced that its own reactor was best suited to meet the requirements of the various nuclear power programmes. Despite this it will be assumed that there is a "united" British view on proliferation.

Whitehall views on major policy issues are co-ordinated through the Cabinet Office via interdepartmental sub-committees. Eisenhower's Atoms for Peace proposals for example were considered in the first instance by the Atomic Energy Official Committee.\(^{(21)}\) Representatives from several government departments participated: the Foreign Office, MOD, Cabinet Office, Commonwealth Office, Treasury, Ministry of Supply, Ministry of Fuel and Power. Major disputes would be settled by the full Cabinet as was MOS opposition to proposals to give responsibility for Aldermaston (AWRE) to the new UKAEA.\(^{(22)}\)

3. APPROACH

British nuclear policy in general and non-proliferation policy in particular touches on four inter-related disciplines: international relations, political science, strategic studies and contemporary history. Several areas within these fields seem particularly relevant; for example, theories of international relations and the decision and policy making process. Some of these theories, models and concepts may be helpful in an examination of British attitudes to nuclear proliferation.

4. POLICY MAKING AND EXECUTION

John Simpson notes that:

There now exists a sizeable literature on the nature of state policy-making and decision-taking which is applicable to the development of nuclear energy.
Although some writers feel that certain of the ideas contained within it are too heavily conditioned by the experiences of the US political system from which it is mainly derived and thus not directly applicable to the British environment, there is little doubt that it offers useful guidelines.\textsuperscript{(23)}

British attitudes to nuclear proliferation involve three specific areas of policy making and implementation: foreign, defence and energy.

Perhaps one of the more important studies of decision making in defence and foreign policy is Graham Allison's The Essence of Decision: Explaining the Cuban Missile Crisis. This describes several models of bureaucratic behaviour. In the Government Politics Model Allison argues that:

the "leaders" of bureaucratic organisations are viewed as a diversified group who act in terms of no consistent set of strategic objectives but rather according to various conceptions of national, organisational and personal goals with decisions being made not by a single rational choice but by the pulling and hauling that is politics.\textsuperscript{(24)}

Thus decisions are the outcome of internal bureaucratic in-fighting. Strobe Talbott's study of the arms control policy process of the Reagan Administration is a case in point.\textsuperscript{(25)} Inter-Agency disputes in Washington between the State Department, Department of Defense, Arms Control and Disarmament Agency, National Security Agency, the White House, Office of Secretary for Defense, and Joint Chiefs of Staff eventually produces an arms control "policy" of sorts. Walter Patterson's unofficial history of civil nuclear power paints a similar picture of British civil nuclear decision-making. In particular, the conflict within the nuclear industry over reactor choice
suggests that decisions are outcomes of bureaucratic battles rather than rational choice. (26) But as Garthoff notes in his study of American Soviet relations from Nixon to Reagan: "Domestic political interests and factional political manoeuvring, the cybernetic and institutional roles of constituencies and interest groups, and the political needs of policy makers may all be as important in shaping actual policy and action in world politics as ideological, geopolitical, world-order, economic or other foreign policy interests and objectives of those decision-makers." (27) This seems a suitable caveat for a study of British attitudes to proliferation.

5. POLICY MAKING AND IMPLEMENTATION IN TECHNOLOGICAL AREAS

In the British government policy process decisions are, theoretically, a matter for ministers. Politicians are required to preside over complex scientific and technological subjects. The quality of these decisions and the role of the civil service has been criticised, the generalist tradition in particular. According to Butcher the classic indictment of the civil service "generalist" philosophy was made by Thomas Balogh. He argued in 1959 that in a planned economy, the crossword puzzle mind, reared on mathematics at Cambridge or greats at Oxford has only a limited outlet. (28) Christopher Herzig, Head of the DEN's AED in the mid 1970s, had a degree in classics. Civil servants are thus dependent on the advice of the scientific staff of the UKAEA and MOD. Roger Williams quite properly points out that nuclear decisions in common with others in technology emphasise the contrast between the horizon of decision makers, measured at best in years, and the time scale of the technology measured in decades. (29) It is not clear that the long term potential proliferation implications of the Atoms for Peace programme were fully considered by the Americans or British. Eisenhower's original proposals of December 1953
were made without any clear idea of what was required or involved.

Politicians are called upon to make decisions on highly complex technical subjects. Joel Barnett, Chief Secretary to the Treasury during the Labour Governments 1974 - 1979, highlighted Eric Varley's 1974 decision to opt for the SGHWR in preference to the PWR for the Third Nuclear Power Programme as an example of the non-specialist politician required to choose between two reactor systems with no real qualifications to do so other than his office. (30) Sir Martin Ryle has remarked that Ministers may have, "inadequate technical background to appreciate the proposals they recommend. must simply rely on what they are told by their permanent civil servants. These civil servants may in their turn be inadequately qualified to advise on such complex issues." (31) However ministers and civil servants draw on the specialist advice of their scientific staff. Both the MOD and DEN have sections responsible for nuclear matters, ACSA(N) and the Safeguards Office for instance. Although the FCO is the lead department on arms control and non-proliferation issues it has no scientific staff of its own and is thus dependent on the MOD and DEN. Advice on civil nuclear matters comes almost entirely from the UKAEA and BNFL; indeed many of the nuclear scientists in the DEN are former UKAEA personnel. (32)

During the early 1950s before formation of the UKAEA the scientists and engineers responsible for nuclear programmes at the MOS were practically the only source of nuclear knowledge in the UK. Sir John Cockcroft, Head of AEE Harwell provided the AE(O) Committee and the Cabinet Defence Committee with advice on nuclear exports, on the potential production of significant quantities of fissile material in particular. However, scientists and engineers may advise the government, and offer technical opinions if
called upon to do so, but non-proliferation policy is not made by the UKAEA or BNFL. Policy is reserved for government. At the end of the day neither the Authority or BNFL's views "matter a row of beans" as governments may choose to ignore their advice.\(33\) In other words decisions may be taken for "political" rather than sound "technical" reasons; for example, the AGR may have been chosen instead of the PWR in 1965 because it was a British design.

However, this does not exclude the possibility that the UKAEA, BNFL or the NNC have their own corporate interests which may differ or conflict with government policy. On matters of exports neither the NNC or BNFL are in a position to export materials without Government approval. There have been occasions when the nuclear industry was keen to go ahead with contracts but were prevented by the Government. On reactor choice, however, the UKAEA's views have had a decisive impact on government policy. Illustrating the inadequacies of technical decision making in complex technological areas in the British government process is to say nothing fundamentally new; however, how nuclear decisions are made and implemented is relevant to an examination of British attitudes to nuclear proliferation.\(34\)

6. DECLARATORY DOCTRINE AND ACTUAL POLICY

In defence and foreign policy there is not necessarily a direct correlation between public ministerial or official statements and actual policy. There may be several 'policies' or attitudes. Indeed as Dunworth notes, "the truth about the events and arguments leading to decision-taking has, in many cases, only a modest resemblance to published statements."\(35\) Professed unity may conceal internal disputes and bureaucratic battles, or policy execution may be diametrically opposed to declaratory
policy. Recreating policies, perceptions and the context of the past from published events has pitfalls. Desmond Ball in his study of US nuclear war plans of the 1940s and 1950s notes a fundamental difference between the declared policy of massive retaliation based on city-busting and actual plans which reveal an emphasis on counterforce targeting; that is, military and industrial targets. (36)

Rather than exclusive focus on Soviet cities US war plans such as Trojan of May 1949 called for the destruction of Soviet oil refineries, especially those producing aviation fuel. (37) Furthermore, Ball observes that "senior Administration" officials could still say in the 1970s that targeting plans should be revised to include options in addition to the indiscriminate mass destruction of enemy civilians is a measure of the extent to which realities of US strategic force employment/action policy have generally not been appreciated." (38)

US war plans, targeting objectives and priorities have remained broadly consistent since the late 1940s despite public utterances which suggest frequent fundamental changes.

The research work of Ball and Rosenberg (39) on US war plans and nuclear forces provides a useful framework for a study of British nuclear policy since it highlights the existence of a clear distinction between "declaratory doctrine" and 'action policy'. A similar state of affairs may have existed in the British case not just in targeting doctrine but also between 'public policy' and actual non-proliferation policy. However, published policy statements by and large convey at least some real concerns and objectives and often much of the underlying policy approach.

It is also necessary to identify and to understand the factors which shape the assumptions behind the policies. Here the relationship between doctrine and technology is particularly germane. For example, what factors were instrumental in the expansion of the US nuclear stockpile?
Was it an increase in productive capacity, delivery system and improved warhead design - technology, or revised operational and targeting requirements - doctrine, which was responsible? In the Soviet case can deployment of heavy missiles with a counterforce potential be interpreted as a direct consequence of a Soviet decision to provide weapons for use rather than deterrence - doctrine, or merely because Russian technology is incapable of producing smaller, more sophisticated systems - technology? In other words, at one extreme technological determinism propels the arms race whilst at the other doctrinal imperatives are responsible. Conversely neither interpretation may adequately explain decisions and events. As an alternative David Holloway concludes in relation to the Soviet case that, "in looking at the relationship between doctrine and technology in Soviet policy ... it should not be supposed that either the formulations of doctrine, or the progress of technology, have eliminated the human - the political, social and cultural-factor from Soviet thinking about war."(40) This may equally apply to British thinking about nuclear proliferation. Three areas of British nuclear history are particularly relevant here: the nuclear weapons programme, reactor policy, and export policy. All of these have played their part in shaping British attitudes to proliferation, though to what extent is unclear.

7. DEPENDENCE AND INTERDEPENDENCE

Robert Keohane and Joseph Nye attempt to describe the international political system, in particular the behaviour of states, in terms of the above concepts.(41) Dependence is defined as a state of being determined or significantly altered by external forces. Interdependence most simply defined means mutual dependence.(42) The key to this particular paradigm seems to be that there are no absolutes: no complete dependence and no complete self-
States however try to minimise the impact of dependence on external sources of vital raw materials, energy especially. Two other concepts are relevant here: vulnerability and sensitivity. Vulnerability suggests a greater degree of dependence than sensitivity since, as Keohane and Nye argue, "in terms of the costs of dependence, sensitivity means liability to costly effects from outside before policies are altered to try to change the situation. Vulnerability can be defined as an actor's liability to suffer costs imposed by external events after policies have been altered."(43) These concepts might help to explain why states embark on military and civil nuclear programmes. For national security reasons a state may seek to reduce dependence for its military and energy security on an unreliable or potentially unreliable external source. It may be possible to explain, in part, British nuclear energy policies in these terms. If so, this has implications for attitudes to proliferation

8 INTERNATIONAL REGIMES

Since there is much discussion in the relevant literature of the "international non-proliferation regime", it is worth touching, briefly, on the concept of "international regime."(44) Most simply defined a regime is a set of rules together with the administrative arrangements for their implementation and enforcement. An international regime, according to Mason however, "consists of rules agreed between a number of states to regulate matters of common concern."(45) In the nuclear case the common concern is the prevention of weapons proliferation without jeopardising the continued use of civil nuclear power. Mason goes on to note that, "international regimes may be incorporated in formal interstate agreements."(46) In the international non-proliferation regime the foremost agreement is the Non-Proliferation Treaty. The British quickly recognised that no one state could unilaterally impose its views on the international regime without creating tension
and instability, something which the British regarded as inimical to the integrity and effectiveness of the emerging non-proliferation regime. As Mason notes:

A further constraint on the effectiveness of regimes i.e. on the degree to which they bring about the outcomes intended by the regime makers, is that regulation is an arms-length management technique.... states do not, however, abandon objectives simply because they are not completely attainable.... regime politics are accordingly characterised by states' continuous attempts to improve regime effectiveness.(47)

It is interesting to note the British contribution to the evolution of the non-proliferation regime in light of this observation. This will be looked at in greater detail in chapters 8,9,10,11 and 12.

9 MAIN THEMES OF THE THESIS

The essential objective here is to identify and explain the factors which have shaped British attitudes to nuclear proliferation since 1952. Several of the approaches and concepts outlined in the preceding sections provided a framework for analysis. A combination of historical political, strategic and economic factors have shaped British attitudes to nuclear proliferation.

The extent to which the early British military and civil nuclear programmes shaped subsequent perceptions of the proliferation issue is an important consideration. The relationship between civil and military nuclear technology is crucial here on three levels; first, the basic technical connection; second, the actual physical relationship in the British programme - dual purpose plants, and third, British understandings of the long term
proliferation implications of these relationships. This raises questions on the level of British understanding of the implications of nuclear technology. For instance it is possible that the civil-military relationship was not fully understood. Those involved may argue, possibly retrospectively, that the civil military relationship and proliferation risks were very much in mind. But this may not be explicit in available documentary evidence. Conversely those scientists and engineers involved may have fully understood the problem, and there was no need to state the obvious. To have done so would have been, as one senior BNFL official put it "to teach your grandmother to suck eggs".

This could well be a rationalisation after the fact: an attempt to justify or explain past policies in terms of current knowledge and with the benefit of hindsight. This is not inconceivable as Lord Hinton has remarked on the state of knowledge in the early 1950s when he described the Windscale Piles as "monuments to our initial ignorance". It is possible that there were differences of opinion within the nuclear community. The nuclear consortia for example may have paid less attention to the possible proliferation implications of reactor exports. Furthermore, scientists at Harwell may have favoured and indeed welcomed the lifting of the veil of secrecy from nuclear technology occasioned by Atoms for Peace. Conversely the staff of Risley may have preferred to maintain secrecy for commercial rather than security reasons.

It is not possible to discuss the British military programme without considering the "special relationship" between the US and UK. As Margaret Gowing notes in the official history of the nuclear programme up to 1952 American policies played a decisive role in the emergence of an independent British programme. The impact of the
1946 McMahon Act on British thinking may have extended well beyond the 1950s. The Act excluded the British from access to American information and materials even though British scientists had played a leading role in the Manhattan Project. This suggested to successive British governments that non-proliferation policies based on technology denial were ultimately counter-productive: they did not prevent the Russian or British nuclear programmes; on the contrary, in the British case US policies actually encouraged the independent British programme. In short, if technology denial did not work in the 1940s there was no reason to suppose that it would in the 1950s, 60s, 70s and 1980s. Changes in US non-proliferation policies in the 1970s, which tried to reintroduce tighter controls in contrast to the "free trade" of the "Atoms for Peace" era, led to considerable disruption to the international nuclear market, and had a major effect on national decision making processes in relation to energy policy. These developments appear to have impressed upon successive British governments the value of a stable and predictable international non-proliferation regime. If states could not be sure of access to the materials and technologies they needed for their national energy programmes from foreign supplies, they would be more likely to create their own independent sources of supply. However, if uncertainty and unpredictability in the international nuclear market could be reduced, the incentives to "go it alone" would also be reduced. In particular, it would be desirable if nuclear fuel cycle plants could be confined to as few states as possible, provided the owners of existing plants were prepared to make fuel cycle services available to those who had a legitimate need.

It is not clear how the rationales and objectives of the civil and military programmes which emerged in the 1940s and 1950s have influenced British attitudes to proliferation. Initial observations of the 1952-1982
period appear to show a continuity in British civil and military nuclear policies. However it is important to recreate the context of the major decisions and perceptions and assumptions which underpinned then it is important for example, to ascertain what factors were brought to the attention of the Cabinet when it considered the proposed first nuclear power programme at the end of 1954. It seems that availability of energy and a perceived inability of the beleaguered coal industry to satisfy the demand amplified the attractions of nuclear power. Much has been written on energy security issues, again more so in the US than UK.\(^{(49)}\) Energy is considered a security issue. Secure energy supplies are closely linked to economic development, thus any interruption to supply or uncertainty poses a fundamental threat to a state's security. Nuclear power was perceived to have potential benefits from a security perspective. This appears to be the case with the British fast reactor programme. Here the possibility of energy self-sufficiency looms large.

Equally important was the desire to export nuclear reactors, components and materials notwithstanding the basic technical relationship between civil and military nuclear technology. The extent to which commercial objectives were balanced by, secondary to, or superseded security considerations is particularly relevant to British attitudes to proliferation. Consequently there may well be an inherent contradiction in trying to prevent proliferation whilst simultaneously encouraging the spread of civil nuclear power. The usual line of analysis of British export policy is to explain why British industry only managed to export two power stations while the Americans, Canadians, French and West Germans were more successful.\(^{(50)}\) Moreover, since several British participants regard the real proliferation risk as the training of foreign scientists, engineers, chemists, metallurgists and physicists, the British contribution to the diffusion of knowledge and expertise is clearly relevant to any study
of Britain and proliferation.

It is necessary to look at the British civil/military relationship; programme rationales and objectives; nuclear export policy and the military programme before seeing how these have influenced British attitudes to, and policies on, nuclear proliferation. Part I discusses these issues. Part II examines the relation between these factors and the British role in the negotiations on the NPT between 1965 and 1968; the 1975 and 1980 Review Conferences; the IAEA and Euratom safeguards systems; the International Nuclear Fuel Cycle Evaluation; the Nuclear Suppliers' Group; International Plutonium Storage, Regional/Multinational Nuclear Fuel Cycle Centres and the Committee on the Assurances of Supply. This thesis covers the period 1952 - 1982.
1. INTRODUCTION

In September 1945 Attlee observed that:

the successful manufacture of bombs from plutonium shows that the harnessing of atomic energy as a source of power cannot be achieved without the simultaneous production of material capable of being used in a bomb. This means that the possible industrial uses of atomic energy cannot be considered separately from its military and security implications.\(^{(1)}\)

This central factor has to be taken into account in any non-proliferation strategy. The relationship between civil and military nuclear technology is, however, only part of the problem. Political considerations are equally important. Two questions arise here: why do states embark on civil and military nuclear programmes? An analysis of British attitudes to nuclear proliferation must first take into account not only the British understanding of the civil-military relationship, but also the objectives and rationales for the domestic programmes. It is necessary to establish exactly why the British embarked on a civil programme of nuclear power. Furthermore, the civil programme's relationship to the military programme is also relevant. The 1950s are of particular interest since the British approach to the control of nuclear technology in the Atoms for Peace era corresponds to the same period which witnessed the launch of the British civil programme, and the expansion of the military programme. These interrelated factors may have proved fundamental in the
shaping of subsequent British attitudes to proliferation. In 1945 it appears as if the basic technical connection between civil and military technology was clearly understood by the political leadership. However, it is not clear from the 1950s that the same level of understanding was evident. In 1953 the British enthusiastically supported the Atoms for Peace programme. This called for the worldwide diffusion of the benefits of the atom for peaceful purposes. Subsequently Atoms for Peace was criticised because it had not considered the long-term proliferation implications, and seemed to mark a retreat from the Acheson-Lilienthal report which pointed to the inseparability of civil and military nuclear technology. In the eyes of subsequent commentators the political leaderships of both the US and UK willfully ignored this. 

It is, therefore, necessary to establish whether the "security implications" of this policy were adequately considered, and if they were why was Atoms for Peace endorsed given the civil-military relationship. The objectives and underlying motives of such a policy also need to be established. These can only be understood with reference to the British civil and military programmes. To this end this chapter will cover three interrelated topics:

(i) the nature and extent of the civil-military relationship in Britain and whether the implications of this were taken into account;
(ii) the extent to which proliferation was considered as a major problem and how this affected international co-operation and nuclear exports;
(iii) the rationales for the civil programme, reasons for the 1954 decision, and influencing factors.

These questions will be discussed with reference to two key documents of the early British civil nuclear programme: the Waverley Report - the future organisation of the atomic
energy programme; and the Trend Report which was an evaluation of the economics and objectives of a civil nuclear power programme.

2. THE NATURE AND EXTENT OF THE CIVIL-MILITARY RELATIONSHIP IN BRITAIN.

Once the military programme had successfully produced an atomic bomb in October 1952, resources were made available for a civil programme. This sequence of events was to have an important bearing on British attitudes. The plutonium production piles at Windscale wasted the heat produced by the fission process. However, in 1952 it was proposed to proceed with a full-scale design study of a natural uranium pilot power reactor - PIPPA (Pressurised Pile Producing Power and Plutonium).(3) Final approval was not given until March 1953. Although originally specified to "produce plutonium as a by-product of power it became a reactor producing power as a by-product of plutonium."(4) The need to satisfy the Chiefs of Staff's increased demands for plutonium was the principal reason for the switch (see Chapter 3).

Responsibility for design and construction of PIPPA was handed over to Risley with Christopher Hinton in charge.(5) The first reactors were officially opened in October 1956 at Calder Hall. The Magnox reactors at Calder Hall in addition to producing weapons grade plutonium also provided a test bed for the First Nuclear Power Programme. Sir Roger Makins, UKAEA Chairman January 1960 to February 1964 wrote that:

Operation of the Calder reactors has also supplied massive evidence on the performance and life of fuel elements. The primary purpose of these reactors was the production of plutonium for military purposes, and their fuel elements were not in fact designed for
the long irradiation which it is necessary to achieve for economic power production...

In addition many experiments have been carried out in the Calder and Chapelcross reactors on prototypes of the fuel elements which have been specifically designed for use in the civil power station.\(^{(5)}\)

Even the Windscale Piles were used for such experiments.\(^{(7)}\)

The extent to which PIPPA was a military programme can be seen from Ministry of Supply (MOS) and UKAEA files from 1952 to 1954. The British Electricity Authority (BEA) were keen to become involved with the nascent civil nuclear programme. In particular they sought to operate the proposed PIPPA reactor. However, the Atomic Energy Board (AEB) of the MOS was not well disposed to the idea. In April 1953 F.C. How of the MOS noted that the:

> proposal that the BEA should operate PIPPA raises an important point of principle which would require the express approval of Ministers because what is done about PIPPA may set the pattern for the future development of atomic power in this country.\(^{(8)}\)

The following month in a memo submitted by the AEB to the Official Committee on Atomic Energy the reason for BEA exclusion from the project is made clear:

> In view of the "military" function of the Calder Hall Plant, the fact that BEA will have no interest in plutonium production, the experimental nature of the power plant, and the fact that from BEA's point of view the project is "educational", the MOS must design, build and own the plant, and retain broad control of its method of operation.\(^{(9)}\)
Production of military-grade plutonium requires short irradiation periods and frequent loading and unloading of the reactor. This would make the reactor uneconomic from a commercial perspective since the reactor should be operating for as long as possible with the fuel left in the core for much longer. It was to avoid clashes of interest that the MOS sought complete control. As the MOS noted, "the priority of the military requirements means that the plant may not be operated in the most efficient manner from the point of view of power production."(10)

It is important to note, however, one of the principal reasons for BEA interest in PIPPA. The Authority were anxious to gain experience of a nuclear power plant, and be in a position to choose between atomic and other types of power station. Furthermore, the BEA wanted to reach such a position as soon as possible because, in their view, this would be necessary, "to relieve the difficult coal prospects of the early 1960s". Experience gained in operating the Calder Hall plant, "would help materially toward that end."(11) Thus for the BEA at least nuclear energy was considered a possible solution to uncertain energy supplies.

Subsequently the Calder Hall reactors became primarily power producers when the military demand for plutonium came to an end in 1964. However, these reactors plus the four at Chapelcross remained available for military use and for this reason they were excluded from IAEA/EURATOM safeguards provisions.(see chapter 10) Until 1971 these reactors were operated by the UKAEA and subsequently by BNFL. The Magnox reactors operated by the CEGB and SSEB were not used for military purposes. However, this issue is contentious. Although governments have insisted that no civil plutonium has been used for military purposes either in the UK or US, critics nevertheless have alleged that as much as 4 tonnes of plutonium originating in CEGB/SSEB reactors have been so
used. The most detailed calculation, that at least $2.3 + 0.8$ te of UK civil plutonium is in destinations other than those given by the government, was made at the Sizewell B Public Inquiry.(12) BNFL, the Department of Energy, and the CEGB deny that this is so. Irrespective of the accuracy of either position the central point is that the situation arose precisely because the civil programme grew out of the military programme. At the Sizewell Inquiry Dr Donald Avery of BNFL noted that for BNFL plutonium was defined "civil" or "military" not by its point of origin, the CEGB interpretation, but by its ultimate end-use.(13) The co-processing of irradiated levels from BNFL, CEGB/SSEB reactors at Sellafield is the closest contact between the civil and military programmes. A clearer understanding of this connection and British attitudes to it, and the proliferation implications may be established from the internal discussions prior to the launch of the first nuclear programme.

When the Cabinet discussed the first nuclear power programme in December 1954 the Lord President of the Council noted in his memo to the Cabinet that the, "civil programme would not compete with military requirements for fissile material which were covered up to 1960 by facilities already existing or under construction."(14) Indeed Ministry of Defence support was contingent on the understanding that the civil programme would not prejudice the arrangements to be made for meeting military requirements for fissile material after 1960. It thus appears that the civil programme was conceived as being apart from the military programme. Furthermore, the Trend Report which examined the economic basis of a nuclear power programme observed that the Report was confined to the development of a nuclear civil power for civil purposes. The Report's Introduction went on to note that, "the exclusion of the military aspects of nuclear fission, particularly the military demand for nuclear materials has
probably resulted in an incomplete analysis of the course which a "civil" programme of development would in fact follow."(15)

Although the Report noted that, "Any reactor in a "civil" programme would need to be designed with the output of power as its primary function."(16) in other places the Report is ambiguous. In the introduction it is noted that the military aspects of nuclear development would need, in practice, to be integrated with any civil programme.(17) This may be plausibly interpreted to mean the dual-purpose fuel cycle facilities. It was not intended, for economic reasons, to build separate enrichment fabrication or reprocessing facilities.(18) The reactors would, however, remain separate.

In the Cabinet memo, The Production of Power from Nuclear Energy, submitted by the Lord President of the Council one possible outcome was considered. In 1954 military requirements for fissile material were only formulated as far as 1960-61. This would be satisfied "by the facilities built at Windscale, Calder Hall and Capenhurst." But,

If the military demand for fissile material were to be increased the Authority might be able to meet the additional requirement from the output of a prototype reactor which they will be building in any case for the civil programme. If this were started in 1957, significant quantities of plutonium should be available by 1961. If this source seemed likely to be inadequate, the Authority would propose to meet any additional military demand by building additional reactors for military purposes, the reactors being of the same type as those being built, either as prototypes or for commercial operation, for the civil programme.(19)

In an emergency, however, it would be possible for fissile
material to be taken from the civil reactors for military purposes". But,

this could not be done without disrupting the development of the civil programme. It should, however, be possible to build up distinct military and civil programmes...providing the military requirement can be formulated sufficiently far in advance. The method proposed would, moreover, enable the best use to be made of the scarce skilled manpower, where a clash between the two programmes could most easily occur, as the reactors required for the two programmes would be of the same design.(20)

It would seem that the civil programme was initially conceived as being separate from the military programme; CEGB/SSEB Magnox reactors would not be dual-purpose as the Calder Hall reactors were. There were ready reasons for this. A reactor operating on a military fuel cycle is ill suited to commercial operation. This was particularly sensitive at the time because if the economics of nuclear power were to be properly assessed such interruptions would damage the civil programme. But it was noted that in extremis plutonium derived from ostensibly civil reactors could be used for military purposes. The Totem series of nuclear tests in October 1953 had proved this.(21) This was not the ideal situation. Subsequent government statements that a civil programme is not the best road for military programme are based on British experience in the 1950s.

Despite this initial consideration the Paymaster-General announced in August 1957 that three of the new civil power stations were being modified to produce military grade plutonium. Amidst renewed COS demands for plutonium the original recommendation that the civil programme could be used for the military programme in an emergency was about to
be fulfilled. The decision suggests that the blurring of the civil-military distinction was not considered an important enough reason to prevent this. One possible outcome of such a decision was noted by Arthur Palmer, Labour/Co-op MP for Cleveland:

I believe the decision is probably a mistaken one and likely to make our nuclear power stations, as potential exports, far less competitive than they would have been. Already we have failed to secure certain contracts for the construction of nuclear power stations in Western Europe. These have gone to the Americans instead and if we persist in this kind of thing we shall find ourselves losing other valuable contracts.\(^{(22)}\)

In defending its decision the Government noted that the alterations, primarily to the fuel discharge gear, would not impair the efficiency of the Magnox stations. Moreover, as these reactors "produced plutonium anyway" it was prudent to make preparations to take advantage of this should the situation warrant it.\(^{(23)}\) The lack of both parliamentary and government concern about the proliferation implications of blurring the civil military distinctions suggests that this was not considered a problem in the 1950s.\(^{(24)}\) In the event only one reactor was modified, Hinkley Point, since the US UK Mutual Defence Agreement of 1958 made the additional production of military plutonium unnecessary. In exchange for UK plutonium the US traded highly enriched uranium and tritium. By 1960, moreover, a further four plutonium producing reactors had come on stream at Chapelcross.

The root of this problem is arguably attributable to historical accident. In Britain the military programme preceded the civil programme so when the civil programme was launched it shared the same fuel cycle facilities. But as Attlee had noted such reactors still produced plutonium.
It seems clear that the British realised that although not preferable such material could be used if CEGB/SSEB reactors operated on a typical civil fuel cycle. This would produce usable but not ideal plutonium for military purposes. These reactors could be modified to run on a military cycle, but at considerable cost to their commercial operation. Despite these factors, as will be discussed in Chapter 4, the British were still prepared to export such reactors. From this it seems reasonable to conclude that on one level the civil-military relationship was fully appreciated, but on another there did not appear to be any realisation that the civil-military programmes should be kept separate. This can be seen from the Waverley Report and Cabinet discussions on nuclear exports and international co-operation.

In 1953 the MOS was responsible for atomic energy. Lord Cherwell, however, considered the direct civil service control unsatisfactory. Civil service control would, in Cherwell's view, delay progress. Cherwell argued that the atomic energy programme should be removed from the MOS and a new organization established which would have more commercial freedom. In the summer of 1953 a committee under the Chairmanship of Viscount Waverley was established to examine the future organization of the atomic energy programme. (25) Cherwell's proposal was highly contentious. In particular, the MOD were opposed to the removal of the Atomic Weapons Research Establishment (AWRE) from their control. The MOS and the MOD were concerned that they should be in a position to exercise general control of the work done by AWRE. Neither Ministry was keen on any proposal which might delay weapons work. For example, since the object of the exercise was to give greater autonomy to the atomic energy project, responsibility for weapons would force the government to keep a tighter grip over the corporation than would otherwise be necessary. (26)
As the Committee took evidence it became clear to its members that given the resources, constraints and differing operating requirements between civil and military fuel cycles it made no sense to separate the two programmes. Completely separate programmes would have required separate fuel cycle facilities; for example, a 'civil' reprocessing plant, and a 'military' reprocessing plant. This was made clear in the Waverley Report's conclusion:

We have... reached the view that it would be quite wrong to try to split the atomic energy project into two parts and to set up a specialist organisation without responsibility for the military aspects - which will long continue a major, though not perhaps in the future a dominant, part of the entire UK project. It is in our view desirable that there should be more and not less cohesion in the atomic project. Separation of the civil and military aspects would we think be wasteful in manpower and effect. Further, since the optimum conditions for the generation of power and production of fissile material are not the same, the corporation would, if it had no direct weapons responsibility, inevitably tend to give priority to the power requirements. This would lead to continuous dispute which might be disastrous to the military effort.(27)

Rather than separate the civil and military programmes the Committee was recommended, on grounds of practicality and resource constraints, to ensure that the new organization had responsibility for all aspects of the atomic programme. However, once the civil programme was launched in 1955 these reactors would not be used for military purposes. But for Britain in the mid 1950s, as the Report itself noted, "the military effort is dependent on the industrial and cannot be satisfactorily separated from it."(28) In other words, the nuclear weapons programme would remain dependent on the production of fissile material in the
Calder Hall reactors and the fuel cycle plants which fabricated and processed the nuclear fuel.

The Waverley Report's recommendations were discussed by the Cabinet in August 1953. Cabinet conclusions recorded that the debate, "turned mainly on the question whether AWRE should be transferred, along with the remainder of the atomic establishment, to the proposed new corporation."(29) However, both the Minister of Supply and Chancellor of the Exchequer expressed doubts. Lord Cherwell endorsed the report noting, "the project would destroy the whole balance of the organisation proposed". More significantly, Cherwell drew the Cabinet's attention to the fact, "that the type of fissile material best suited for industrial use was not the type best suited for use in atomic weapons. A corporation concerned only with the industrial application of atomic energy would be biased in favour of producing the material most suited for industrial use."(30) Two projects would lead to an unnecessary and wasteful duplication of resources and compromise the effectiveness of both civil and military programmes.

Despite the arguments of the MOS, that AWRE should remain its responsibility, the majority of the Cabinet, "were disinclined to abandon the main principle of organisation recommended by the Waverley Committee."(31) This was because the Cabinet, "were also impressed by the Committee's conclusion that the military effort would be dependent on the industrial and could not be satisfactorily separated from it."(32)

It was agreed in principle that the basic recommendations of the Committee should be accepted. However, the outstanding issue on the supply of atomic weapons was subject to further discussion between the Ministry of Supply and the Paymaster General. The Cabinet Conclusions of 25 August, 1953 detail the essence of the agreement. Basically, the services would order atomic weapons from the
MOS which would then place contracts with the UKAEA for, "development associated research and production of the atomic cores and of such other components of Atomic weapons as might be agreed."(33)

Despite the recognition of the relationship between civil and military nuclear technology the British were still keen to make the benefits of civil nuclear technology available worldwide. The Waverley Committee was prevailed upon by the Commonwealth Relations Office and Foreign Office to recommend that contacts with overseas states should be maintained. The CRO noted in its memo to the Committee that:

There will be every reason to develop the closest possible contacts between the proposed organization in the United Kingdom and the authorities concerned in Canada, Australia, New Zealand and South Africa. (34)

But it was noted that, "special care will be required in dealings with India, Pakistan and Ceylon where security considerations may cause problems."(35) The Foreign Office assumed in its memo that contacts with overseas countries would occur, but was keen to ensure that these would not be pursued without FO involvement. On all matters of external policy the FO recommended that the new organization should be under obligation to consult a Government Committee with FO representation. Presumably this was to ensure that due weight was given to security considerations. At this time responsibility for atomic energy within the FO came under the Permanent Under Secretary's Department. This is, perhaps, an indication of how seriously the foreign aspects of nuclear energy were taken. Indeed once the UKAEA was established it had to seek FO approval before proceeding with any contact with overseas countries and organizations.(36)
The debate on the future organization of the atomic energy project indicates three things. First, the basic civil military nuclear relationship was clearly understood and recognised at the highest political level. But this would confirm Simpson's observation that, "until the early 1960s there was no clear vision of the need to make a sharp distinction for non-proliferation purposes between the military and civil aspects of nuclear power."(37) However, the decisive factor here was that Britain was a nuclear weapon state first before its civil programme started. There was no need to maintain a separability; moreover, economic and resource constraints dictated that this should be so.

Second, it was clear that as the optimum conditions for the production of military-grade plutonium and power are not the same, it made little sense to use civil plants for military purposes. In the 1970s British officials argued that if a state sought nuclear weapons it would build dedicated facilities rather than interfere with civil nuclear power stations. This argument appears to be based on British experience; however, it is a shade disingenuous since the British were prepared to use plutonium produced in ostensibly civil reactors for military purposes. The allegations at the Sizewell B Public Inquiry that this has in fact happened despite official denial demonstrates the fundamental fact recognised by the Waverley Report. Civil and military programmes cannot be satisfactorily separated in a nuclear weapon state.

Finally, the Waverley Report seems to suggest that the fundamental civil-military relationship was recognised by the highest political leadership in the mid-1950s. It is not clear, however, that this was fully taken into account when British nuclear exports were under consideration. In particular, the long-term proliferation implications of the Atoms for Peace programme were either not considered at
all, or the "security" implications were not fully appreciated. There appears to be some confusion in official thinking. Exports were acceptable even though the nature of the civil-military relationship appears to have been understood. This would suggest support for Atoms for Peace was a deliberate and considered policy, proliferation was not considered a likely consequence. It to this topic that we now turn.

3. NUCLEAR EXPORTS AND INTERNATIONAL COLLABORATION

Margaret Gowing notes that the state $\textit{which}$ US non-proliferation strategy was aimed in the immediate post 1945 period was the Soviet Union. The Combined Development Trust, for example, was designed to deny uranium supplies to the Russians. COCOM established in 1946 sought to prevent the supply of, amongst other items, nuclear materials and technology to the Soviet bloc. However, both the Russian and British nuclear tests demonstrated the weakness of policies based exclusively on denial.

The British themselves were limited in what they could pass on to other states because of their close wartime collaboration with the US. Indeed the Quebec Agreement of 1943 qualifies as the first non-proliferation agreement. This prevented either the British or Americans from "communicating any information about the atomic energy project to third parties."(38) Although a wartime agreement this set the tone for post war British policy since this clause remained in effect.(39) The British were determined to resume the level of wartime Anglo-American nuclear collaboration which the 1946 US Atomic Energy Act had foreclosed. Thus circumspection and caution in discussing or exchanging nuclear information with third parties, even Commonwealth countries, were standing orders. Gowing notes that the British were anxious to do nothing which would frighten off renewed American interest in collaboration.(40) It was largely for this reason that the
British supported the Atoms for Peace programme. But this was not the only reason. The British were keen to extend contacts with Commonwealth and European states; however, American sensitivities remained a major consideration. This can be seen from examination of several cases in 1952 and 1953.

In June 1952 the Belgians asked the British to assist them to build an experimental reactor. The Paymaster-General reported this to Cabinet. It was "gratifying" that the Belgians had approached the British rather than the Americans. Moreover, Cherwell said "it was desirable that the Belgian's work on atomic energy should be developed in association with ourselves."(41) However, the principal reason for British interest was the need to retain access to uranium ore in the Belgian Congo. For Cherwell it was important to retain Belgian goodwill since the existing uranium contract was due for renewal in 1956.(42) The need to maintain access to scarce uranium ore and desirability of involvement in Belgian civil R & D were, in Cherwell's mind, sufficiently important reasons to comply with the Belgian request, the slight security risks notwithstanding. It is sufficient to note here that the British were favourably disposed to the spread of civil nuclear power. Indeed during the Whitehall interdepartmental debate on the Waverley Report the establishment of a possible "export trade in atomic reactors" was one of the issues which influenced the organizational changes.(43)

Interest in atomic energy was not confined to Belgium. The FRG was also anxious to begin work on an atomic research programme. This posed several problems largely on account of West Germany's post war position and Allied control over German society. British Cabinet Defence Committee discussions on a FRG request for assistance suggests that proliferation implications of civil programmes were considered. However, the desirability of encouraging such programmes was also evident.
In the spring of 1952 Konrad Adenauer asked for permission to manufacture 2000 grams of nuclear fuel per year. Sir John Cockcroft advised the Defence Committee that:

it would be preferable to express any agreement in terms of maximum obtainable power rather than in terms of plutonium output... an output equal to that of BEPO should be more than adequate for German requirements for isotopes... From the point of view of the manufacture of atomic weapons either by the Germans or other capture by an enemy the amounts of plutonium involved in a pile of 4MW are negligible. (44)

The following day the MOS pointed out to the Committee that it would be more difficult to control the size of the pile once it was established. Furthermore, it was also noted that it was exceedingly difficult to control works of this kind, and in any case it was not possible to contemplate imposing strict control on German manufacture for many more years. The Foreign Secretary took the view that it was already agreed that there should be a complete prohibition on the production of atomic weapons by the Germans. They were, however, not prohibited from some form of development work in atomic energy. (45) It was suggested by the Paymaster General that it would be more valuable to limit the size of the research reactor. But the Germans should be prohibited from building a reactor in excess of 4MW even though it would produce 1500 grams of plutonium a year. However, if it was used for military purposes it would take five years to accumulate sufficient material for one bomb.

Despite this reservation the Defence Committee recommended on 2 May that:

it would be more logical and more consistent to add to our acceptance of the German Chancellor's proposal for a production of 500 grams of nuclear fuel on the
condition that the FRG should agree not to build an atomic pile capable of producing more than this amount annually, i.e. a pile whose total heat output would be equivalent to 1.5MW. (46)

Two observations may be made here. First research on civil nuclear R & D should not be prohibited on non-proliferation grounds provided certain security requirements were fulfilled. Second, if civil nuclear R & D, albeit on a limited scale could be permitted in the FRG, which was a special case in light of its post-war status as an occupied state, then it could also be allowed in other non-Soviet bloc states. This appears to have become the basis for the control of nuclear exports. Proliferation considerations alone were not sufficient to preclude contact with overseas nuclear organisations and governments. Furthermore, the extraction of government assurances was to be the principal guarantee that civil facilities and materials would not be used for military purposes until the IAEA safeguards systems emerged in the 1960s.

In January 1954 the Cabinet discussed Commonwealth co-operation in atomic energy. Australia and South Africa in particular were the key states. As with Belgium in 1952 access to uranium was not far from British considerations. Lord Salisbury, Lord President of the Council, wrote that there were "strong arguments in favour of going ahead with closer contact with Australia." (47) Military rather than non-proliferation considerations were important here. The British Chiefs of Staff suggested that if Australia, "developed a power plant of her own, and if this plant were constructed to run as to produce military plutonium, this would be a valuable strategic source of supply to the UK." (48) Given the shortage of fissile material at this time such a view was understandable. Since the Australians did not build any power reactors there is no way of telling whether the COS proposal would have been acceptable. But the British were still dependent on Australian goodwill for
facilities for testing nuclear weapons. This was one ready reason to agree to assist the Australian civil R & D programme. Furthermore, the future nuclear export interests of British industry must have been behind the fear that if the British "withheld technical information, the Americans would step in instead."(49)

In the Annex to Lord Salisbury's memo the longterm interests of the British civil programme seem to be clear:

The UK Government are very willing that their technical information in regard to all aspects of the industrial application of atomic energy should be made available by them to the Government of Australia as may be required by the progress of the Australian atomic energy programme... When the time comes to build power stations in Australia, we should as far as our resources permit, assist with the design and operation of these plants and supply of special material that may be required such as natural uranium fuel elements and graphite.(50)

Similar considerations were evident in discussion of a South African request for assistance. Even though Combined Development Agency natural uranium supplies from South Africa were committed up to 1964:

it is clearly in our long term interest to play in with them and to encourage in every way their present desire to look to us for help. We should therefore follow up the South African initiative by offering to receive South African technicians for training here.(The only practical step open to them at this time).(51)

Consequently the Lord President recommended the Cabinet to authorise release of all information and technical
assistance as both Commonwealth states "might need for their atomic energy work."(52) The Cabinet agreed it would be prudent to provide what information was possible in the hope that this would mark the beginning of a greater Commonwealth effort in atomic energy. Proliferation considerations were not ignored however. The Americans would have to be consulted lest such a move prejudice the prospects for Anglo-American nuclear collaboration.

Lord Salisbury pointed out the necessity, "for agreed arrangements to be made to ensure that appropriate security safeguards operate on a common basis in regard to classified information."(53) If the Cabinet agreed to the recommendation it would be "necessary to approach the United States government before we can release classified information about atomic energy in Australia". This was motivated, arguably, not so much for fear of Australian proliferation, but rather that information would find its way to the Soviet Union. Indeed as Gowing noted, "the Americans were specially dubious about Australian security."(54)

These three incidents seem to indicate a somewhat ambiguous approach. On the one hand the "security" risks in making the peaceful uses of atomic energy available appear to have been fully appreciated. Conversely this of itself was not sufficient reason to deny states the benefits of civil atomic energy. However, this basic approach formed the basis of British attitudes in subsequent years. The interest in establishing a nuclear export market, for reactors and fuel, is evident from the Cabinet deliberations. Nevertheless as the Anglo-American relationship was crucial, care was taken not to compromise the prospects for resumed collaboration. Information was needed for the military programme rather than for civil purposes. In short, the Anglo-American relationship was crucial in the formation of British attitudes to non-proliferation. Once close military co-operation was
resumed in 1958 it became a central objective of British policy to do nothing which might put the military co-operation at risk. By the 1960s British nuclear exports were not, by and large, inhibited by deference to American sensitivities. In particular the fuel cycle services of the UKAEA and subsequently BNFL did not always meet with US approval. URENCO and THORP in particular are good examples. This will be discussed in Chapters 5 and 6.

4. RATIONALES FOR CIVIL AND MILITARY PROGRAMMES: WHY DO STATES EMBARK ON NUCLEAR PROGRAMMES?

The parlous state of the British coal industry was an issue which exercised the minds of both Labour and Conservative governments in the first decade after the war. Allied to this was the economic crisis, the balance of payments deficit especially. This was the context in which the civil nuclear programme emerged. Until 1952 civil nuclear power had taken second place to the military. Despite this scientists at Harwell and Risley were aware of the potential of nuclear power for the generation of electricity.

Study of a nuclear reactor designed to produce power was underway in the Ministry of Supply and the Ministry of Fuel and Power at the end of 1951. A MOS technical committee, "believed that the need to supplement the nation's supply of electrical power was so urgent that the necessary effort should be made available for a bold attack on the problem."(55)

When the proposals for the first nuclear power programme were before the Cabinet in December, 1954 the Lord President of the Council noted, "it was now established that the generation of electricity from atomic energy was technically feasible and was likely to prove, within the next ten years, competitive with electricity generated by conventional methods."(56) This latter assumption was
based in particular on the continuing production problems of the coal industry. Moreover, the economic crisis was equally important here. Secure and stable energy supplies would be necessary for recovery. In 1952 the Chancellor of the Exchequer had continually pointed out the weakness of the British economy. All commitments could not be maintained. A choice had to be made between exports and rearmament. The Chancellor pointed out, somewhat axiomatically, that, "to remain a great power we must first of all have enough economic strength, since it is only on this basis that military strength can be supported."(57)

Coal production was a problem. Output of high quality coal in particular was small. This had been the conclusion of the Trend Report which laid the basis for the first nuclear power programme. The supply of coal would remain a difficult problem for a number of years.(58)

the maximum development of any supplementary means of generating electricity (provided that its cost is not uneconomic) will be welcome at the earliest possible moment - the more so since, whatever the long term future of the coal industry may prove to be, the problem of coal supply will remain acute for as long as we can foresee.(59)

The urgent need to reduce the balance of payments deficit, as in the immediate post 1945 years, necessitated the export of coal thus reducing stocks for electricity generation. There were other reasons to reduce dependence on coal. Before the Trend Report was issued in October 1954, the Minister of Fuel and Power submitted a memo to the Cabinet on 18 May. His observations on the future were pessimistic unless remedial action was taken:

..if nothing further is done, we are likely to find ourselves in two or three years time in much the same position of general coal stringency that has existed
since the war. At present the stranglehold of the miners can be absolute. By a three weeks strike in
the winter, which they could well afford, they could bring our whole economy to a standstill. By less
extreme means, they could put us in extreme difficulties.(60)

The Minister concluded that:

After prolonged consideration and discussion with
the nationalised fuel and power industries, I am
convinced that we cannot reasonably expect coal
production to increase in the short term at a faster
rate than consumption is rising... apart from regular
imports of coal, there is no practicable short-term
way of relieving the stringency of the coal
situations except by injecting more oil into our fuel
economy. We must choose either to adopt this oil
policy or to continue the previous government policy
of drift. There is no third possibility for the next
ten years.(61)

Although nuclear power was not considered an immediate
solution, the prevailing climate clearly influenced both
the Trend Report and subsequent decision to endorse the
Report and authorise the first nuclear power programme.
Indeed the Trend Report concluded:

that the initial stages of nuclear power would
involve appreciable risks. But there would be no
less risk in denying ourselves the possibility of
reinforcing our supplies of fuel.(62)

Furthermore, although the problems with coal production
would remain until 1963 this was sufficient to justify the
development of nuclear power. Even though nuclear power
would not, initially, be fully competitive with
conventional power the risk was worth taking.(63) It was
not a question of ensuring absolute energy security but rather of reducing the risks inherent in undue dependence on an unreliable source. Nuclear power could contribute to this desirable objective even if it were not economic when compared to conventional power. This factor appears to have been crucial in subsequent years as nuclear power continued to be supported by Governments (see Chapter 7). For example, reduction of dependence on the coal industry was one of the principal arguments used by the CEGB to justify their case for a PWR at the Sizewell B Public Inquiry. (64)

The memo before the Cabinet on the Production of Power from Nuclear Energy echoed the conclusions of the Trend Report:

In the absence of nuclear power, coal consumption by the power stations would rise in the same period from the present level of 36 million tons a year to about 100mt a year so placing an increasing and probably intolerable strain on the coal industry. (65)

However, the key observation combined both the energy security objectives with the potential export potential which might be derived from a nuclear power programme. This was an irresistible combination:

It is important to embark on a civil programme now in order to ensure that this country is in the forefront of the development of this new technology. In addition to the economic advantages for the fuel situation at home, there would be commercial advantage of putting our engineering consultants and industry in the position to sell abroad power reactors and the associated plant, equipment, materials and technology and there would also clearly be a political advantage in being first in the field, which should enhance our influence in both foreign
and commonwealth countries. (66)

The first nuclear power programme was announced publicly in February 1955 with the publication of Cmnd 9389 A Programme of Nuclear Power. Two factors appear to have been crucial in this decision. First, uncertain coal supplies required action to reduce the dependence on it. Roger Williams noted that "the economic rationale of the first nuclear power programme ... derived from the threat of an energy gap." (67)

In the aftermath of Suez in 1956 uncertainty over future oil supplies led to the trebling of the original nuclear programme of 2000MW. Given the background to the 1954 decision the reasons for this are not difficult to ascertain. Williams advances several: possibilities of a 40m ton gap in coal availability by 1965; and growing balance of payments cost for energy imports. (68) Although the expanded programme was scaled down, the basic rationales remained unaltered. Despite subsequent problems with the civil programme, the disastrous industrial structure and disagreements over reactor choice, nuclear power continued to be seen as a necessary contribution to British energy security.

Second, the prospect of reactor exports and associated fuel services was a key consideration in both the Trend Report and the Programme of Nuclear Power. Subject to security considerations this remained an important element in British domestic nuclear policy, the debates over reactor choice in particular. Moreover, it was also to play an important part in British non-proliferation policy.

If nuclear power was necessary, if not indispensible for British energy security, then it was likely to be so for other states. Not only would this provide, hopefully, a market for British nuclear hardware, but would need to be taken into account in any practical non-proliferation
strategy. As can be seen from the discussions on the early 1950s these objectives need not be mutually exclusive. This relationship was to become much more pointed in the 1970s, but it seems as if assurance of supply which would maintain energy security was the crucial point here. This had been a critical factor in the formation of British domestic nuclear policy.

The American policy of technology denial in the 1940s had not only encouraged an independent British nuclear programme, but brought home the fact that this was counter-productive. Stable relationships were much more desirable. This in turn became central to British export policy in subsequent years.

5. CONCLUSION

Decisions taken in the 1950s appear to have decisively shaped British attitudes to nuclear issues. The basis for subsequent non-proliferation policies was laid in this period. The durability of the rationales for the civil programme can only be explained by reference to the early debates and the conditions in which the decisions were taken. The three interrelated issues discussed here, civil-military relationship in the UK, nuclear exports and proliferation concerns, and rationales for the civil nuclear power programme set the agenda for future British discussions on the same issues. Whilst they may not entirely explain positions adopted in the 1960s, 1970s and early 1980s, the seminal period of the early 1950s may, as a Times editorial in August 1984 noted, "result in present day policy intractables being analysed more clearly if put against a fuller record of the past than is conventionally available."(69)
CHAPTER 3

BRITISH NUCLEAR WEAPONS PROGRAMME: BRITAIN AND VERTICAL PROFILERATION.

1. INTRODUCTION

Although Britain was the first state to decide to build a uranium bomb in 1941,(1) the first British test came eleven years later in October 1952. Furthermore, it was not until November 1953 that the first operational British nuclear weapons were deployed.(2) The British weapons programme illustrates some of the problems likely to be encountered by any "medium power" which decides to build its own nuclear weapons. The least of the problems is the creation of sufficient fissile material since the real difficulty, as the British case shows, is the creation of a credible delivery system which is always in danger of becoming obsolescent before deployment. The design and construction of delivery systems in Britain has continually undermined any pretence of technological and logistical independence even though declaratory doctrine emphasises "independence". Central to the discussion of the weapons programme is its relationship to the proliferation issue, and the relationship between technology and doctrine. Is it doctrine or technology or a combination of both factors which lock a state into the arms race spiral? An understanding of the context and basis of key British decisions in the 1950s in particular may provide a much deeper understanding of recent British nuclear weapon decisions and their relationship to the British position on non-proliferation.

Although the term vertical proliferation is mainly employed to describe the quantitative and qualitative expansion of the super-powers' nuclear arsenals, it may also be an appropriate description of the British weapons programme since 1952. There is, for example, a considerable
qualitative difference between the first generation nuclear bombs and the warhead being designed for the Trident SLSM which is the smallest ever designed by Aldermaston. It is therefore important to discover to what extent the proliferation implications of the British programme figure in British attitudes to the proliferation issue in general or on British non-proliferation policy in particular. It would appear that throughout the period 1952-1982 successive British governments have rejected any suggestion that continued British possession of nuclear weapons has had any impact on "horizontal" proliferation.\(^{(3)}\) This chapter proposes to show that the British nuclear weapons programme has developed largely independently of consideration of the proliferation problem. British security requirements take precedence over non-proliferation considerations. However, the experience of the early British military programme has shaped the later declaratory view that nuclear proliferation is primarily a political problem. Any advanced industrial state can build nuclear weapons. All that is required is a political decision to do so. This fundamental fact was recognised by Attlee as early as November 1945. The British weapons programme confirms this.\(^{(4)}\)

2 BRITAIN AND NUCLEAR WEAPONS 1952-1962

At the end of World War 2 it was assumed by almost everyone involved in the wartime project that Britain should possess nuclear weapons. By the time a Cabinet sub-committee, Gen 163, authorised a weapons programme in January 1947, "a well established and considerable atomic energy programme already existed."\(^{(5)}\) The decision was no doubt made easier by this than if the programme needed to be built up from scratch.\(^{(6)}\) The weapons project itself, however, proceeded independently of an aircraft designed to carry them. The aircraft were designed in ignorance of the specifications, weight, length and diameter of the weapons they were supposed to carry.
Indeed the medium bomber requirements were laid down on 17 December 1946 almost 2 months before the formal political decision to build the bomb was taken. The V-Bomber programme envisaged a ten year developmental period; in short, the full complement of aircraft would not be ready until 1957 at the earliest. In terms of resource allocation production of fissile material took priority.

The principal objective of British policy between 1946 and 1952 was to re-establish the close collaboration with the US which had characterised the Manhattan project. The British were totally cut-off from US secrets. There were advantages however as Lord Hinton noted, "it is the best thing to have happened to us. The Americans have built a complex of plants in an incredibly short-time - a magnificent scientific and engineering achievement - but they built them under pressure of wartime conditions and the worst thing in the world we could do would be to blindly follow them. We have got to think for ourselves - and it was a very good thing." However, if Britain could demonstrate a nuclear weapons capability; that is, by testing a device, only then would the US be more be more forthcoming with atomic secrets. Churchill refused to support the doubling of plutonium production until he had time to discuss Anglo-American co-operation with the newly elected President Eisenhower in 1953. Despite this there were limits. The British government refused to allow US access to British warhead design information, even though William Penney was prepared to accept terms of co-operation negotiated in 1951 with "strings attached."

In October 1953 the Ministry of Supply's Atomic Energy Board considered it "essential to ensure that they (Americans) do not have access to atomic weapons information of any description." It was not until 1958 that significant exchanges of warhead information took place. More will be said about this below. The Anglo-American nuclear relationship is central to the
proliferation issue. The period 1946 to 1953 was seminal in the formulation of British attitudes to nuclear proliferation. The success of the independent British programme established the futility of non-proliferation policy based on denial of technology and information. Worse still, such policy proved counter productive since American action encouraged the independent British programme. The nature of Anglo-American co-operation following 1958 is indicative of the basic British conception of the proliferation question. The 1958/59 Mutual Defence Agreement has in practice blurred the distinction between civil and military nuclear technology even though the Atoms for Peace programme required that the two should be separate.

3 PLUTONIUM PRODUCTION 1950-1957

Authorisation was given to build two natural uranium, graphite moderated air-cooled plutonium production piles in May 1947. Each pile was designed to produce 45 kgs of plutonium per year when worked up to initial design capacity.(13) In 1947 Hinton felt that given additional modifications production could be pushed up to 70 kgs. The decision to build two air-cooled piles instead of one water-cooled pile was justified, amongst other reasons, on the grounds that, "we should be taking a short step in the right direction to the development of industrial power."(14) The subsequent gas-cooled civil nuclear power programmes owe their origins to this decision. The power output of each of the Windscale plutonium production piles was planned at 1 MW per ton of uranium metal fuel. Each pile was to contain 150 tons, hence the maximum power rating of 150 MW. Risley predicted a conversion ratio of 0.9; that is, 0.9 atoms of plutonium for each atom of Uranium 235 destroyed.(15) In the original Cabinet specification an annual production of 90 kgs of plutonium was called for. This would be sufficient for 15 bombs per annum. As Gowing notes, however, the original conversion
ratio was a miscalculation and consequently plutonium production never reached design levels.\(^{(16)}\) Despite this the number of bombs available was not reduced. Improvements in warhead design at Aldermaston resulted in greater economy in use of fissile material. Therefore if 90 kgs per year was enough for 15 bombs, 6 kg per weapon, an annual production rate that did not involve any reduction of 15 bombs per year corresponds to an eventual output of 75 kgs of plutonium with 5 kgs per weapon. Until 1983 there had been no public estimation and breakdown of the plutonium output from the Windscale piles. However, John Simpson in *The Independent Nuclear State* produced the following figures based on public sources:

<table>
<thead>
<tr>
<th>WINDSCALE</th>
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<th>2</th>
<th>TOTAL</th>
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<tr>
<td>1951</td>
<td>14</td>
<td>10</td>
<td>24</td>
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<tr>
<td>1952</td>
<td>19</td>
<td>26</td>
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<td>1953</td>
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<tr>
<td>1958</td>
<td>21</td>
<td>25</td>
<td>46</td>
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However, Atomic Energy files from 1950 to 1957 in addition to the aforementioned performance of the Windscale piles suggest slightly higher figures. The material in the PRO files refers to the operating record of the piles.\(^{(17)}\) In Atomic Energy Progress Reports to the Minister of Supply No 58 September 1950 it was noted that the probable output of Pile No 1 would be 60% for the first 18 months of its operation after which it would rise to design level. No 1 pile diverged on 26 July 1950. In January 1951 the pile operated at a level between 40 and 50 MW and continued at this level for some months. No 2 pile diverged in June 1951 and was expected to achieve its design output from the outset; however, it was not until the end of August that
the complete charge of 150 tons of uranium was loaded. It was then proposed to raise the output to 100 MW in the first week of September. Until May 1952 both reactors operated without incident. Despite a series of modifications to the reactors during September and October, the end of 1952 saw them operating according to plan.

It is, however, difficult to calculate precisely the amount of plutonium produced. Some of the available information is contradictory; for example, a reference to the relationship between thermal rating and plutonium output in a natural uranium reactor states that 1.4 MW(th) is equal to an annual production of 500 grams.\(^{(19)}\) Therefore a reactor operating at 100 MW would produce 35.7 kgs of plutonium annually. Since Aldermaston was more economic in its use of plutonium, an annual output of at least 35 kgs is not inconsistent with an output sufficient for 15 atomic bombs per year.

The tenor of the half-yearly reports for the Windscale works between 1955 and 1957 suggest that there were no problems with operating performance and output. In October 1953 the piles were loaded with enriched uranium metal. This increased plutonium production because of the increased number of U235 atoms. A revised plutonium production table, derived from these observations might look like this:

<table>
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<tr>
<td>1950-51</td>
<td>27 kgs</td>
<td>27 kgs</td>
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<td>1951-52</td>
<td>27 &quot;</td>
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<tr>
<td>1956-57</td>
<td>38 &quot;</td>
<td>38 &quot;</td>
</tr>
</tbody>
</table>

Simpson appears to be incorrect to assume that tritium
production in the piles reduced plutonium production.\(^{(20)}\)
This will be discussed in detail below. For the moment it is sufficient to note that a design alteration to the production piles to allow tritium production did not interfere with planned output of fissile material.

4 OPERATION HURRICANE

Although the first British atomic device was not tested until 3 October 1952 there is evidence to suggest that the British had made substantial progress in warhead design. This can be seen from comparison with the yield and efficiency of the first US tests in 1945 and 1946. The Fat Man Assembly, and presumably the Mark III derivative, contained 6.1 kgs of plutonium.\(^{(21)}\) The Nagasaki bomb had a yield of about 22 kt, but an efficiency of about 17\%. The complete fission of 1 kg of fissile material corresponds to an explosive yield of 17.5 kilotons.

Efficiency is derived from the equation \(E = \frac{Y}{M} \times 17.5\) where \(Y\) = yield and \(M\) = mass in kilogrammes. As discussed above the most probable quantity of plutonium used in the first British warheads was 5 kg. Gowing implies that Operation Hurricane used less than 6 kgs.\(^{(22)}\) Although the actual device weighed about 5 tonnes, it had a yield of 25 kt corresponding to an efficiency of 27\%.\(^{(23)}\) This suggests that British scientists had developed a more efficient implosion mechanism even though Penney noted in 1946 that production of precision conventional High Explosive lenses for the trigger would be very difficult.\(^{(24)}\) During Cabinet discussion on the reorganisation of the atomic energy programme, Duncan Sandys, Minister of Supply, noted that the British had successfully made and exploded an atomic bomb superior to the Bikini model.\(^{(25)}\) As William Penney was present at the Bikini tests in 1946, Sandys' statement is not the product of fancy.
NSC 68 was, arguably, the key document in US defence policy in the 1950s. The British equivalent was the Defence and Global Strategy paper prepared by the British Chiefs of Staff at Greenwich in the summer of 1952. Given the economic crisis, the balance of payments deficit in particular, a reappraisal of defence expenditure was imperative. The report was a response to the development of nuclear weapons and the urgent need to reduce defence expenditure. It was in this climate that nuclear defence as an economic alternative to large conventional forces was established. In particular the large scale conventional rearmament programme launched during the Korean war was a drain on scarce resources, steel especially. Steel was required to contribute to the export drive which was necessary to alleviate the acute balance of payments problem. The key conclusion, as the COS themselves stated, was that:

provided the deterrents of atomic air power and adequate forces on the ground in Europe were properly built up and maintained, the likelihood of war would be much diminished and we could in consequence ease our economic position by accepting a smaller and slower build-up of forces, equipment and resources for war.

The implication is clear: Britain should move to a nuclear based defence policy. For example, the Defence and Global Strategy paper called for a doubling of plutonium production from 90 to 180 kgs per year. The COS were prepared to wait four years for this to be achieved. In numerous memos circulated to the Cabinet, and in statements recorded in Cabinet Conclusions, the Chancellor of the Exchequer makes it quite clear that a substantial reduction in defence spending was required. For example,
the claims of defence and industrial investment and of our best exports are directly and inescapably competitive; they all depend on the same sections of the engineering industry. (30)

and,

in total we are trying to do far more than our resources permit. If my colleagues are convinced that we must carry on the defence programme at its present level, then there must be adequate reductions in our efforts in other directions. (31)

However, as the COS in paragraph 40 of their report stated:

The reductions which we recommend in the build-up and equipment of the forces can be undertaken only by incurring real and serious risks. These risks are only justifiable in face of the threat of economic disaster. (32)

The COS, however, hoped that the effects of the cutbacks could be minimised. It was considered necessary to convince first the US authorities and then the other NATO allies that the real strength of the Alliance, "would not be impaired because there would still exist the powerful deterrent in the shape of atomic air power and adequate forces at immediate readiness on the continent." (33)

Crucially, the US JCOS were in "general agreement" with British views "on the longer term". They did not, however, accept the concept of "broken backed" warfare. (34) In March 1953 the Cabinet Defence Committee had before it a memo submitted by the COS entitled NATO Air for 1952. UK Contribution To NATO Forces At The End Of 1954. Here the shift from primarily conventional to nuclear defence is made clear:

The RAF provisional force goal for the end of 1954
falls short of the Lisbon planning goal by more than a quarter. This is due primarily to reductions on financial grounds in the aircraft production programme, but also on the decision consequent on the approval by the Government of the COS survey of defence policy and global strategy to limit the production of tactical aircraft and light bombers in favour of later production of medium bombers. (35)

In November 1954 the proposed plan was to build up the Medium Bomber Force to a front line strength of 240 aircraft. To achieve this and maintain the front line strength until 1962 required the purchase of 330 aircraft at a cost of about £160 million. Production capacity, however, was limited to four bombers per month. This would result in a front line strength of 144 aircraft in 1958. To increase this to 240 by 1958 required expansion of monthly production capacity from four to nine aircraft. (36) It was for this reason that output of tactical aircraft suffered. The notion that nuclear defence was a more effective and cheaper mode of defence than additional divisions and tanks remained fundamental in British nuclear thinking throughout the period 1952-1982. (37)

Even though the Defence and Global Strategy review was forced on them by economic circumstances, the COS nonetheless were convinced of the strategic value of the new doctrine. Sir John Slessor, for instance, noted that his objective when discussing the Review with the US JCOS:

would be to obtain their general acceptance of the strategic concept proposed not only because it was economically inevitable but also on the grounds that it was militarily sound. (38)

Thus the US New Look Defence policy which was broadly similar was prompted by the British.
The first British test in 1952 had to reconcile the interests of the scientists and the military. From the scientific perspective it would have been preferable for the device to have been detonated on a tower. This makes it easier to monitor the performance and efficiency of the fission reaction. The COS, on the other hand, were keen to establish the effects of a nuclear weapon explosion on a harbour. This stemmed from the targeting requirements for the nuclear force, and for civil defence purposes.

Although successive governments have maintained that the "independent deterrent" exists purely to deter a nuclear attack on Britain, targeting plans and development of the weapons programme suggest the opposite. This is not altogether surprising. In the US case Alan Rosenberg and Desmond Ball have shown that "declaratory doctrine does not correspond to action policy."(39) Ball, for example, concludes:

American nuclear war plans have always included a wide range of types of targets - military forces, stockpiles, bases and institutions; economic and administrative centres; and, after 1950, the Soviet nuclear forces. Despite the frequent and sometimes quite radical changes in avowed strategic policies and targeting over the past three decades these four general target types of categories have remained remarkably resilient in strategic war plans. (40)

With a much smaller nuclear stockpile, one might expect early British targeting plans to correspond to its publicly declared purpose: to deter nuclear attack or blackmail by threatening retaliatory attacks on Soviet cities. Certainly the RAF could not cover all the targets deemed to be vital by SAC. Cabinet and Chief of Staff documents from 1952, 1953 and 1954 seem to suggest that even in Britain
there was a discrepancy between the declared purpose for the deterrent and actual planning. Furthermore, information revealed to the Australian Royal Commission on Britain's Nuclear Tests further suggests that the British nuclear force was more than a weapon of last resort. The documents reveal three important points. First, the British COS were keen for a much closer relationship with the US Joint COS in nuclear planning. In particular, the COS feared that targets which were of the utmost importance from the British perspective did not figure highly in the US war plans. Second, the types of time-urgent targets discussed indicate a strategy based on counter-force; that is, attack on Soviet military facilities and bases rather than cities. Third, and most important, that in the likelihood of war or major international crisis British policy was identical to SAC's: pre-emptive strike on Soviet nuclear and military forces.

In a report of a meeting between Sir John Slessor and General Ridgeway of the US JOC the minutes of a COS meeting in July 1952 record:

Sir John Slessor stressed the great importance that British COS placed upon the early attack on submarine and mining bases in the Baltic and Northern Russia. It was the opinion of the COS that a mining and submarine attack by Russia would be as serious a threat to our survival as a Russian atomic attack. He hoped that General Ridgeway would use his influence to persuade SACLANT and General LeMay to coordinate their plans for this highly important form of attack.(41)

Indeed one of the purposes of the first British test was to ascertain the vulnerability of ships and submarines to atomic attack.(42) Britain's first plutonium bomb was placed in the armaments room of HMS Plym which was anchored off Trimouille Island in the Monte Bello Islands.
In January 1953 an estimate of the size of the Soviet nuclear arsenal was made in a document entitled *Air Defence Of The UK. Report By The Chiefs Of Staff*:

The UK is already open to long-range atomic attack from Russian bases in the Ukraine and White Russia. By 1954 the Soviet Union may have up to 150 large atom bombs, as well as small atom bombs which can be carried in light jet bombers.\(^{(43)}\)

The planned response of the COS is outlined in the section entitled *The Counter-Offensive*. The title misleads; a preemptive counter-force strategy is implicit here. The intended targets for the planned front-line force of 240 medium bombers seems clear enough:

since the complete immunity from atomic attack can never be guaranteed in the forseeable future, the existence of adequate striking forces as a deterrent is of enhanced importance: should the deterrent fail, it is vital to reduce the threat by countering at source Russia's capacity for long-range attacks. The Chief of the Air Staff has already discussed this requirement with the US Air Staff, and planning is now proceeding for immediate counter-bombardment of the enemy's long-range bomber bases on the outbreak of war. This task must also be one of high priority for our own medium bomber force.\(^{(44)}\)

In a memo to a Cabinet Defence Committee Meeting of 1 October 1953 entitled *Likelihood Of General War With The Soviet Union Up To The End Of 1955*, the COS noted that although possession of atomic bombs might deter an attack, it could "equally well be argued that as the atomic power of both sides grows, so will the temptation to strike the first blow, and that this will increase the dangers inherent in any such crisis."\(^{(45)}\) At this time the COS were not prepared to say which argument had more validity.
This, however, indicates that a pre-emptive attack was considered a possibility by the British COS. Although General LeMay of SAC did not advocate a preventative war he nevertheless maintained that, "if the US is pushed in the corner far enough we would not hesitate to strike first."(46) The British COS appear to have subscribed to the same view.

What appears to be the clearest expression of British targeting plans based on a pre-emptive attack on Soviet military targets is to be found in a memo to the Cabinet Defence Committee submitted by the Prime Minister.(47) In contrast to the US where the political leadership were apparently unaware of the military plans, the British Cabinet of late 1954 was appraised of the proposed targeting requirements for the medium force. The first V-bomber Squadron, however, was not operational until 1955. It is worth reproducing here most of the relevant section on Defence Policy which deals with the Medium Bomber Force:

The medium bomber force is of cardinal importance to the primary aim of our defence policy, namely to discourage aggression by building up powerful deterrents. The main purpose of creating a British bomber force is to put us in a position to knock out Soviet air bases from which attacks would be delivered against this country. In addition it could be used to assist in holding back the Russian land offensive in Europe and could also undertake missions against strategic targets, though we regard these roles as secondary to that of counter-attacking the Russian bomber bases.

In four or five years' time the Russians may be expected to dispose of about 850 jet bombers some of which would be capable of bombing the United States, and all of which would be able to attack the UK. The Soviet long-range Air Force today occupies 40
permanent bases, but we know of at least 150 other airfields in European Russia and the satellites from which these aircraft, and the new Russian jet bombers which are now coming into the force, can operate in war. These bases will doubtless figure amongst the targets to be attacked by the American Strategic Air Force. But we cannot be sure which priority the Americans will accord to them in relation to other targets on their list of bombing objectives. Since the very survival of Britain would depend upon the promptness and thoroughness of the counter-attack against these Russian air bases, it is essential that we should ourselves possess and control a bomber force capable of performing this vital task.\(^{(48)}\)

The full Cabinet hoped that defence planning would be more closely coordinated with that of the United States. For example, the Cabinet Conclusions of 5 November record a note from the Chancellor of the Exchequer, "duplication of effort might be avoided if we knew for certain how far we could rely on the USAF to deal with ...... targets which were of special importance to us."\(^{(49)}\)

Targeting requirements for the medium bomber force do not appear to have been altered by the decision to manufacture thermonuclear bombs in Britain. This decision will be discussed below. For example, Churchill urged his colleagues at a Cabinet meeting held in July 1954 to approve a thermonuclear programme in terms which have been publicly used to rationalise the deterrent. He argued that these weapons were necessary in order to ensure "effective retaliation". However, the aforementioned Defence Memo was submitted to Cabinet in November 1954 by Churchill himself.

The priority given to military targets over purely civil ones is noted by Robert Jackson in his history of the Vulcan Bomber.\(^{(50)}\) Probable target assignments of the early 1960s included fighter air fields, radar complexes,
SAM missile sites in Northern Siberia, naval complexes - submarine bases in particular, such as those at Murmansk and Archangelsk.

Evidence made available to the Royal Commission into British nuclear tests in Australia seems to confirm the view that nuclear planners in Britain thought in terms of counter-force targeting rather than counter-city. Lord Penney, Director of AWRE from 1953-1959, has said that there was strong pressure from the military for a bomb which could be used in a war.\(^\text{(51)}\) Although the first test was in October 1952, it was not until 11 October 1956 that the first air-drop of a deliverable weapon took place. Since the yield was only 3 kilotons this would suggest that the development of a "battlefield" weapon was underway.\(^\text{(52)}\) As will be discussed in the section on the tests, it is clear that one of the principal objectives was to provide the COS with information for offensive and defensive purposes; in short weapons for war-fighting purposes.

Thus from the very beginning of this period it is clear that the British military regarded nuclear weapons not just as a weapon of last resort, but as an active and central part of defence policy. Thus in terms of decision making, Britain's early nuclear programme was equally rooted in doctrine as much as technology. It would therefore appear that the Ball hypothesis applies to the British experience: action or procurement policy does differ from declaratory policy. It is therefore possible that the same applies to non-proliferation policy in general. It may be that policies pursued at one level may be systematically undermined by other policy objectives; for example, MOD interests may conflict with FCO interests. The debate over the plans for a multilateral Nuclear force and Atlantic Nuclear force in the 1960s is a good example. (see chapter 9)
DEPLOYMENT OF THE DELIVERY SYSTEM: V-BOMBERS
1955-1960

Although procurement of atomic weapons was first priority, the platforms for these weapons did not become operational until July 1955. Even then only six Valiant bombers were deployed at RAF Wittering. Since the Valiant bomber could only carry one 10,000 lb MKI nuclear store, the RAF's stock of deliverable weapons was, presumably, only six in mid-1955. The transition from first test to deployment of large numbers of deliverable warheads takes time, even in the case of superpowers like the US and Soviet Union. Although the US had 50 bombs in July 1948, there were only about thirty nuclear capable B-29 bombers. In 1953, however, SAC possessed 1,000 nuclear aircraft. Although the first Russian nuclear test was in August 1949, it was not until late 1953 or early 1954 that nuclear weapons for military use became available. Therefore the slow increase in the stockpile of deliverable nuclear weapons in Britain should not be too surprising. The Valiant bomber, however, was a stop-gap in case the more advanced swept-wing aircraft, the Vulcan and Victor bombers, were either unsuccessful or came too late.

Production of the Vickers Valiant ended in September 1957, by then 108 production aircraft had been built. However, not all of these were assigned nuclear roles. Including the Operational Conversion Unit Squadron at Gaydon, there were ten Valiant squadrons. The other two medium bombers, the Vulcan and Victor, became operational between 1957 and 1962 when the last Victor B2 was deployed. By December 1960 RAF Bomber Command was comprised of the following squadrons:
<table>
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<tr>
<th>No 1 Group</th>
<th>18 squadron</th>
<th>Valiant B1</th>
<th>Finningley</th>
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<tbody>
<tr>
<td>44</td>
<td>&quot;</td>
<td>Vulcan B1</td>
<td>Waddington</td>
</tr>
<tr>
<td>83</td>
<td>&quot;</td>
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<td>617</td>
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<tr>
<td>No 3 Group</td>
<td>7</td>
<td>Valiant B1</td>
<td>Wittering</td>
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<td>49</td>
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<tr>
<td>10</td>
<td>&quot;</td>
<td>Victor B1</td>
<td>Cottesmore</td>
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<td>15</td>
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<td>55</td>
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<td>90</td>
<td>&quot;</td>
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</tr>
<tr>
<td>148</td>
<td>squadron</td>
<td>Valiant B1</td>
<td>Marham</td>
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<tr>
<td>207</td>
<td>&quot;</td>
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Assuming an average of eight aircraft per squadron, though some had only seven, this gives a total of 120 deliverable warheads in the British stockpile.

A squadron, however, did not receive its full complement of 7 or 8 aircraft at once even though it was considered operational. In practice the aircraft were delivered over a period of months. As an example of the rate of delivery the third Vulcan B2 squadron 616 received its aircraft on the following dates:

1st 1 September 1961  
2nd 20 October 1961  
3rd 1 December 1961  
4th 10 January 1962  
5th 1 February 1962  
6th 1 March 1962  
7th 14 March 1962 (61)

This protracted period of deployment was not untypical for
the V-Bomber squadrons which were gradually brought into service between January 1955 and December 1962. Although supplies of fissile material expanded readily enough, production increased by more than 50% during the year 1958-59, (62) the stockpile of deliverable weapons increased at a slower rate. The real quantitative and qualitative expansion of the British nuclear force occurred in the years following 1960.

Even though 1957 and 1958 witnessed the introduction of the first Vulcan B1 and Victor B1 squadrons, the Valiants according to Robert Jackson, "continued to form the mainstay of the RAF's strategic deterrent to the end of the decade." (63) The First Vulcan B1 squadron entered service in July 1957, and in all a total of 45 were built. (64) The last of the V-Bomber designs, the Handley Page Victor, was not deployed until the spring of 1958. Formation of the planned total of four Victor B1 squadrons was completed in early 1960 involving a total of 50 aircraft. (65)

Despite this increased deployment, Jackson notes that not all of these aircraft were assigned nuclear roles. Some were tasked to hit their targets with conventional free-falling bombs. (66) In 1960 the spearhead of Bomber Command consisted of eight Victor and Vulcan squadrons, approximately ninety aircraft in all. Assuming each aircraft carried between one and four gravity bombs, probably two, then we have an upper limit of 360 and a lower limit of 90 deliverable bombs in the stockpile.

By 1960 fissile material production was no longer a problem since there were now eight plutonium reactors in operation with a designed output of at least 45 kgs per year each. However, given the improved operating performances and load factors, the actual figures were probably much higher. (67) Finally the uranium enrichment plant at Capenhurst was producing at its peak between 1959 and July 1962 when the requirement for HEU was fulfilled.
One published estimate of the output of HEU assumes an annual production of 1762 kg. (68) This calculation is based on the following assumptions. Capenhurst's capacity was 400 tons swu per year. At 0.2% tails assay each kilogram of uranium enriched to 90% U235 requires 227 kgs of separative work. Assuming an operating life of five years this produces a total figure of 9810 kgs. As 90% U235 has a critical mass of 26.6 kg, this gives a total of 368 bombs. (69) The eight plutonium producing reactors contributed a total of about 2614 kgs of plutonium between 1956 and 1964 when plutonium production for military purposes was brought to a close. (70)

8 THE BRITISH NUCLEAR TEST PROGRAMME 1952-1958

The twelve full-scale tests conducted in Australia between these dates illustrate four key factors about the nature of the British nuclear weapons programme. There were nine megaton range shots between 1957 and 1958, but these formed part of the thermonuclear development programme. (71) First, it is now clear that the British working independently of the Americans made significant advances. Available evidence suggests that these related primarily to improved yield-to-weight ratios. (72) Second, it is now clear that two of the tests used plutonium with a high PU-240 content. The EMU tests were necessary, "to establish certain minumum characteristics of fissile material for use in nuclear weapons. This information was required urgently in connection with the production of fissile material for military use. It would enable existing or future nuclear reactors, used for this purpose, to be designed and operated, as appropriate, to achieve the highest output at the lowest cost consistent with the efficiency of the weapons." (73) This clearly demonstrates that the British were aware that reactor grade plutonium could be made to explode even though it is not ideal material for military purposes. However it is not clear what percentage of PU240 was involved.
Christopher Hinton observed in relation to the deliberations within the UKAEA on the design of the Calder Hall reactors, that William Penney, "thought that at the higher temperature in the core of a Calder reactor would give more of the higher plutonium isotopes (Pu 240 upwards) than he would tolerate with weapons. The result he thought was that he would get fizzes". However, experiments were carried out which established that Penney "could tolerate plutonium produced from neutrons with a higher energy spectrum." (74) Nonetheless the need to use reactor-grade plutonium was born out of a feared shortage of military-grade plutonium. Thus subsequent claims that civil nuclear power cannot be used for military purposes, or at least not the preferred route, is disingenuous as the British themselves actively considered this route. Third, as mentioned in the section on targeting doctrine several of the tests were conducted for the benefit of the military. The COS were keen to ascertain the effects of nuclear explosions on military equipment and personnel. The minutes of a COS meeting of May 20, 1953 record that:

Many of these tests are of the highest importance to departments since on their results depend the design of equipment, changes in organisations and administration and offensive and defensive tactics. (75)

Thus the Buffalo test series (there were four tests in all) were designed with these criteria in mind. The first two tests were required to test prototype service warheads. The third test was fired partly to obtain scientific data and partly to obtain data on weapon effects. The third test also provided the RAF with the opportunity to drop a nuclear bomb. The fourth test was the test of a service weapon. (76) Centurion tanks, artillery pieces and aircraft were exposed to tests. It would appear that the COS regarded nuclear weapons as tactical as well as strategic. William Penney clearly states:
The military, as I keep stressing, were thinking about nuclear war and in a nuclear war the weapons would be to attack the enemy and do as much harm to him as possible; and a ground burst was a very likely way.\(^{(77)}\)

The nature of these tests suggests that the hypothesis outlined in the section on targeting is broadly correct.

Finally, although the first thermonuclear test was not until 15 May 1957, several of the Australian tests were directly related to the thermonuclear programme. Two of the tests, the Mosaic series, involved experimental fission triggers for fusion weapons. These tests were probably 'boosted bombs'. On 16 May 1956 Sir Anthony Eden wrote to Australian PM Mr Menzies requesting permission in principle for two tests to be carried out. He stated that the experiments would consist of, "atomic explosions with the inclusion of light elements as a boost." Mosaic G2 on 19 June 1956 had a yield between 60 and 98 kt.\(^{(78)}\) This device contained "light" elements, most probably tritium. Tritium gas is injected into the plutonium core to boost the efficiency of the fission explosion by acting as an extra neutron source. Compact high yield fission triggers are necessary for the 'primary' system of thermonuclear weapons. Operation Antler, September-October 1957 was concerned with the trigger mechanism for the thermonuclear tests:

The trials were necessary to help confirm laboratory tests and resultant understanding of the triggering mechanism for high yield thermonuclear tests... Fundamentally, the Antler trials, as had been the Mosaic Trials, were designed to assist in the development of the thermonuclear weapon.\(^{(79)}\)

Although the then preferred material for the fission
primary was U235, these tests all used plutonium. This in itself at the time was a significant technical achievement. In short, the British had made substantial progress on their own without US assistance. It is to the thermonuclear programme that we now turn.

9 THE THERMONUCLEAR PROGRAMME 1954-1958

The British decision to proceed with a thermonuclear programme was taken in 1954. Scientists at Aldermaston were well aware of the theoretical basis of the 'super', and after the demonstration of the practicality of the theory with the US Mike test in November 1952 knew that it could be made to work. Although this decision was not publicly announced until February 1955 on publication of the Defence White Paper, preliminary approval was granted on 16 June 1954 by a Defence Policy Committee. This decision, however, was not formally presented to the full Cabinet until 7 July 1954. Churchill argued that the Cabinet should formally approve the, "proposal that hydrogen bombs should be produced in this country, and should endorse the preliminary action which had already been taken to this end." It appears that technological momentum rather than prior political authorisation was instrumental in the thermonuclear programme. Indeed the Cabinet was asked to endorse a fait accompli. Moreover, the Cabinet had no notice that this issue was to be raised. The Lord Privy Seal said, "he hoped they would not be asked to take a final decision on it until they had time to consider it". The preliminary steps already taken were approved pending a final decision.

However political and strategic factors were present in the process, it was not just a matter of technological inertia. Churchill stated:

that we could not expect to maintain our influence as a world power unless we possessed the most up-to-date
nuclear weapons.\(^{(83)}\)

The relationship between doctrine and technology is closely interwoven. Britain's thermonuclear programme was not purely the result of technological inertia, nor was it brought into existence because of doctrinal requirements.

One of the problems facing the American thermonuclear programme was tritium production. Tritium is produced by irradiating lithium 6 elements in a reactor. The lithium 6, however, absorbs neutrons which would otherwise be captured by U238 and transformed into plutonium. In short, there is a high opportunity cost in terms of lost plutonium production.\(^{(84)}\) Considering the relatively small output of plutonium from the Windscale reactors, the additional burden of tritium production would have reduced this substantially even though only very small quantities of tritium were required.

For the British however this did not appear to be a problem even though Penney remarked that accumulation of sufficient tritium would be a major problem. As early 1947 John Cockcroft, head of the research group at Harwell, requested that facilities in the production piles be made available for production of three isotopes: polonium, carbon 14 and tritium. This design alteration, it was claimed, would not interfere with the planned production rate of 45 kgs per reactor a year.\(^{(85)}\) It was proposed to produce twenty grams of tritium a year. This seems to be confirmed by a statement made by the Lord President of the Council, Minister responsible for atomic energy, at a Cabinet meeting on 7 July 1954 on the thermonuclear programme. Lord Salisbury noted that:

\begin{quote}
If further scientists could be recruited this additional production could be undertaken without serious disruption of the existing programme for the
\end{quote}
manufacture of atomic weapons. (86)

It was also reported, "that much of the material needed for the new bomb would have been required for the production of atomic weapons and there would be a substantial degree of flexibility in the programme since atomic bombs could be converted into thermonuclear bombs." (87) Thus if tritium production resulted in massive inroads into plutonium production, it is unlikely that these statements would have been made.

Cabinet discussion on the thermonuclear programme was resumed at the 48th meeting. The first point to note is that the thermonuclear decision is the only nuclear weapons programme that appears to have been discussed by the full Cabinet. (88) Secondly, although little was said at the time publicly about preventing the spread of nuclear weapons, it was actively considered. Two key questions were raised during Cabinet deliberations on the wisdom of pursuing a thermonuclear programme. First, "might we not wish to prevent the manufacture of thermonuclear bombs in Western Europe, particularly in Germany?" Second, "would it be easier for us to prevent this if we ourselves refrained from producing these weapons?" (89) The eventual outcome of the discussion indicates that for the British "vertical" and "horizontal" proliferation were, and are, separate. The long-term implications of this decision are central to British attitudes to proliferation. Britain already was a weapon state; therefore, "there was no sharp
rejected this proposition. The thermonuclear decision set the precedent. For this reason British non-proliferation strategy has focused on the relationship between civil and military nuclear technology.

The Anglo-American relationship loomed large in the Cabinet discussion on thermonuclear weapons. Despite the amendment of the MacMahon Act in 1954, the British were still denied full access to American nuclear secrets. One of the objectives for the British thermonuclear programme was made clear by Lord Salisbury. He considered:

> that the greatest risk was that the US might plunge the world into war, either through a misguided intervention in Asia or in order to forestall an attack by Russia. Our best chance of preventing this was to maintain our influence with the US government; they would certainly feel more respect for our views if we continued to play an effective part in building up the strength necessary to deter aggression than if we left it entirely to them to match and counter Russia's strength in thermonuclear weapons. (91)

Formal Cabinet approval for the thermonuclear programme was not given until 26 July 1954. (92) Cabinet Conclusions record two rationales for the decision. First, "in order to preserve our position as a leading military power", and second, "to maintain our influence in world affairs it was necessary that we should possess a stock of the most up-to-date thermonuclear weapons." (93) This was one of the two tasks entrusted to the newly established United Kingdom Atomic Energy Authority which was created in the first place to expedite both the military, and particularly the civil nuclear programmes.

Britain's thermonuclear project was a remarkable success. From 16 June 1954 it took only twenty nine months until the first test on 15 May 1957. Sir Edwin Plowden, first
Chairman of the UKAEA, noted in 1954 that the project must be completed in three years rather than the four estimated by the scientists. Political circumstances might conspire to prevent the successful culmination of the project. Plowden presumably had a CTBT, or at least a PTBT, in mind.\(^{94}\) Preparatory work for the May test was well in hand a year before. For example, the Mosaic G1 and G2 tests on 16 May and 19 June were designed to measure whether conditions in which thermonuclear reactions would occur could be generated. For this purpose the devices contained small quantities of thermonuclear material sometimes referred to as "light elements". The purpose of the tests was to obtain information for the first thermonuclear test. These devices were "tests of devices to be used as triggers for an H-bomb."\(^{95}\)

Although U235 was the then preferred material for the fission trigger, the first thermonuclear test used plutonium.\(^{96}\) HEU, however, was manufactured for the first thermonuclear tests of May and June 1957. A major British achievement was that unlike the Americans, the first experimental thermonuclear device was dropped from an aircraft. This test was less than a year after the first US air drop. It appears that the key development related to yield-to-weight ratios. The ballistic case used to house the thermonuclear devices was the Blue Danube which weighed 10,000lbs.\(^{97}\)

Operation Hurricane produced a yield of 25 kt from a five tonne assembly. The Grapple test had a yield of about 1 megaton from a device of similar weight. When compared with the first serviceable US thermonuclear bombs the British counterparts appear to have had a much higher yield-to-weight ratio. In later 1954 the first operational thermonuclear weapon, designated TX-17, entered the US arsenal. This bomb weighed 44,000 lbs.\(^{98}\) Since the Valiant bomber which carried out the test had a maximum payload of 21,000 lbs it is clear that the first British
weapons could not exceed this weight. Indeed, as Duncan Campbell notes the first stockpiled thermonuclear weapon to enter RAF service, the Red Beard, weighed 10,000 lbs. Given the efficiency of the first fission explosion, development of improved yield-to-weight ratios was not beyond the British. Chapman Pincher, however, has stated that the 1957 tests were "flops." This is unlikely. William Penney, first Director of AWRE Aldermaston, a more reliable source, has stated that all megaton range tests came within ten per cent of the planned yields. There were between seven and nine megaton range tests in all between May 1957 and September 1958.

These as Simpson notes, fulfilled a function similar to the US Castle series. The largest of the UK Grapple Tests reportedly produced a yield of 10 MT. When compared to Soviet thermonuclear development it is clear that the British were able to produce high yield weapons much earlier over a given time span. The first Russian 'superbomb' was not tested until 1955, even though work on thermonuclear weapons commenced in 1947-8.

The extent of British progress can be gauged from reports of the first meetings between British and American scientists in 1958. Simpson notes that Edward Teller remarked that even though there had been twelve years of total separation, both sides, "had achieved broadly the same physics understanding". Harold MacMillan was able to boast that British advances had "amazed" the Americans. The real difference between the two lay in the level of resources devoted to the programmes. Here, as Simpson notes, the Americans had a clear advantage since this led to "more sophisticated engineering designs". The British problem was not at the theoretical and experimental lever, rather it was translating act into article. There had been a two and a half year interval between first fission test and deployment of serviceable weapons. The
pattern was repeated with thermonuclear weapons. However, the success at the experimental and demonstrational level provided and confirmed the basis for successive statements by British governments and the nuclear industry that the proliferation issue is primarily a political rather than a technical problem. In short, any industrial state can produce nuclear weapons, all that is required is a political decision to do so. The British programme was a case in point. Furthermore, existence of civil facilities did not mean a state had decided to build nuclear weapons: such a decision would have led to dedicated military plants. Attlee's comment of 1945 was indeed prescient.

The RAF was equipped with serviceable thermonuclear bombs in 1958. However, Pierre gives a date of 1961. When Dr Nyman Levin was appointed Director of AWRE in 1959 it was reported that there were several technical problems to be solved in atomic weapons before their manufacture became a matter of routine. Duncan Campbell, however, maintains that it was US assistance right across the board that contributed to the rapid miniaturisation of British warheads. This, however, ignores the aforementioned British advances in conceptual design. It is more appropriate to argue that the UK incorporated US engineering and assembly techniques as well as components at the two Royal Ordnance Factories at Burghfield and Cardiff which are responsible for nuclear weapons manufacture. In short, the Americans were able to bring the advantages of their extensive resource base to the benefit of the British programme, rather than provide the fundamental concepts and designs. This assistance would not have been forthcoming had it not been for demonstration of independent expertise. There were two reasons for the close collaboration with the Americans: economic and political. Unnecessary duplication of effort was a waste of scarce resources, hence the 1958 and 1959 Mutual Defence Agreements for the exchange of fissile material amongst other things. Politically, collaboration was considered
necessary in order to exercise a moderating influence on US behaviour.

10. BLUE STEEL AND THE THERMONUCLEAR PROGRAMME

In the mid-1950s the Air Staff considered the growing problems associated with strategic bombers. There were two in particular; first, their vulnerability on the ground; and second, the perceived growing effectiveness of Russian air defence. These factors threatened the credibility of the British deterrent before the first generation delivery system was fully deployed. The question mark hanging over the deterrent was instrumental in defining a need for either an intermediate range ballistic missile or a stand-off capability for the medium bomber force. In 1954 an operational requirement was issued for a stand-off bomb. Two years later Avro received a development contract for Blue Steel which was designed to carry a thermonuclear warhead.(107) The Blue Steel procurement history suggests that "technology creep" was playing its part in British nuclear weapons policy. The threat of technological obsolescence was as much a factor in the quantitative and qualitative expansion of British nuclear forces as doctrinal requirements.

In the event it took eight years for Blue Steel to go from drawing board to initial operational capability. The first RAF squadron armed with Blue Steel became operational in February 1963. Subsequently two more Vulcan squadrons and two Victor squadrons were equipped with Blue Steel ASMs.(108) Of the 35 Victor B2s built, only 21 were modified to carry Blue Steel.(109) In addition to this front-line strength it should be noted that other Valiant, until 1964, Victor and Vulcan aircraft were armed with free-fall nuclear and thermonuclear nuclear bombs. Moreover, both the RAF and Royal Navy possessed nuclear capable aircraft armed with tactical weapons.
II. FROM SKYBOLT TO POLARIS

At no time in the period under discussion have British governments regarded Anglo-American nuclear collaboration as a proliferation problem. The fundamental fact remained that Britain was a nuclear weapon state irrespective of any US assistance. Moreover, there is little public evidence to suggest that the proliferation implications of such collaboration were actively considered at the time. It should be noted that Ireland did not table the non-proliferation resolution at the UN General Assembly, which was to lead to the NPT, until 1961. In 1960 the US agreed to supply the British with 100 Skybolt missiles, however, the warheads were to be manufactured in Britain.\(^{110}\) Robert MacNamara, US Defence Secretary, cancelled the Skybolt Air Launched Ballistic Missile programme, a move which threatened the future of the British deterrent since procurement of a credible delivery system was the central British problem.\(^{111}\) However, at the Nassau Conference in December 1962 MacMillan was able to persuade President Kennedy to sell the British 100 Polaris missiles instead. The Polaris decision demonstrates the British contribution to what is called vertical proliferation. A choice, however, had to be made between the Polaris A-2 and A-3 systems.

Both Polaris A-2 and A-3 were produced by Lockheed; however, as of 1962 the A-3 was an unproven system. The main difference between the two was range, A-3's was much greater. Indeed the Treasury did not care for the unknown and would have opted for the proven A-2 system had the decision been theirs. However, A-3 it was to be, and according to McGeoch, the decision was taken by Solly Zuckerman and Peter Thorneycroft.\(^{112}\) When presented with a choice between two weapon systems, the British opted for the more sophisticated A-3 in preference to the qualitatively inferior A-2. This was not the last time
that such a decision was made, and resolved, in favour of the more advanced system.

It should be noted that the construction and deployment of the Polaris force roughly corresponded to the negotiations in the ENDC on the NPT 1965-1968. As the neutral and non-aligned states were insisting on the inclusion of "Article VI" in the NPT at Geneva, the British were quantitatively and qualitatively expanding their nuclear stockpile. However, it should be noted that the British were careful to ensure that the NPT did not prohibit Anglo-American nuclear collaboration. The approximation of the Polaris project with the NPT negotiations would seem to bear this out. US assistance was not insubstantial.

Although the missiles were American, the warheads and submarines were of British design and construction. Duncan Campbell argues that the British Polaris warhead was a straight copy of the American W58. Peter Malone, however, suggests that because of a temporary breakdown in the US and UK technical collaboration occasioned by US suspicions of the Labour government's intentions, the design of the re-entry vehicles was slightly different. The design decisions, moreover, were made at Aldermaston in the absence of American information. Despite this the Americans supplied the HEU (oralloy) and tritium for the warheads in addition to the launch and firing control mechanisms; the gas system for underwater ejection of the missiles; the ships inertial navigational system; and the HEU for the Resolution class submarine PWRs. Perhaps the most crucial US assistance is the satellite information used for navigation and targeting.

Polaris replaced the Blue Steel armed Vulcans and Victors as the principal deterrent; however, some of these aircraft
were retained in a nuclear-capable role. Therefore an increased target coverage was made possible by the gradual increase in not only the number of nuclear warheads stockpiled in Britain, but more importantly in the total number of deliverable warheads. Desmond Ball argues that, "questions of targeting are central to any serious discussions of nuclear strategy." Thus, the increased target coverage made possible by the Polaris project is one very practical way of gauging the extent of British vertical proliferation.

It appears that the greatest rise in the number of available warheads occurred in the 1960s and early 1970s. This illustrates two fundamental features of British government thinking on the proliferation question. First, in the view of successive governments the NPT does not prevent either the modernisation or expansion of British nuclear forces. In fact the NPT recognises Britain as a weapon state. Despite the provisions of Article VI British governments in practice had defined proliferation in horizontal rather than vertical terms. As the thermonuclear decision made clear, the ability of the British to prevent proliferation would not be compromised by British possession of nuclear weapons.

Keohane observes that British rationales for an independent deterrent are potentially quite subversive of the non-proliferation regime; for example the British programme in the 1950s encouraged the French. Second, this separation of the British nuclear weapons programme from non-proliferation strategy provided the basis of the British position at both the 1975 and 1980 NPT Review Conferences. For the British there is no contradiction between their nuclear weapons programme and their opposition to nuclear proliferation.

Even though the British nuclear weapons programme does not compare either quantitatively or qualitatively with those
of the superpowers, it demonstrates a commitment to remain in the nuclear club. The Chevaline programme is evidence of not only this commitment but also the technological pressures which contributed to the Polaris modernisation programme. It also should be noted that from initial research in 1967 to its initial operational capability in 1980, Chevaline corresponds to the first years of the NPT. Available evidence suggests that the Polaris modernisation project was pursued without consideration of the proliferation implications. If they did enter into the deliberations it is clear that the precedent set by the thermonuclear decision won the day. Nuclear weapons are seen as fundamental to British military security. Worthy though the objectives of non-proliferation may be, they cannot compromise British security interests.

Technological creep also played its part in the Chevaline programme. Having designed the warheads, the next task was to work on ensuring their survivability and penetrability. Intelligence reports of Russian ABM developments called into question the ability of the Polaris warheads to penetrate any defensive system. This provided the spur for what became the Chevaline programme. In 1967 AWRE began a research project geared to designing a warhead capable of evading any ABM system.\(^{(120)}\) Aldermaston's work drew on US concepts developed under the Antelope project of the early 1960s. In late 1970 the project was granted more regular status. However, it was not until the beginning of 1974 that there was a clear decision by the government to proceed with Chevaline.\(^{(121)}\) The essential characteristic of the new system was that it is a manoeuvrable space craft rather than a nuclear warhead.\(^{(122)}\)

There were two major problems with the Chevaline programme. First, the cost had, as a Defence Secretary John Nott stated, "gone bananas."\(^{(123)}\) From an original estimate of £175 million the final bill amounted to £1 billion. Second, and the principal reason for the budget overrun, is
made clear by Geoffrey Dillon:

In almost all respects the organisation and management of the Chevaline programme was the complete antithesis of the Polaris programme. It failed to meet its time and cost estimates and failed to perform to specification or time.\textsuperscript{(124)}

Despite these two serious problems Chevaline does demonstrate that any state determined to build nuclear weapons and prepared to allocate the necessary resources can overcome the technical and engineering problems. As in the civil programme poor organisation and management caused more problems than any lack of basic nuclear expertise.

The new front-end, designated A-3 TK, is not a MIRV; however, its destructive footprint is larger, the impact points span about 70 km. Defence White Papers in the early 1980s made it clear that the new system, "does not involve any increase in the number of warheads associated with the Polaris force."\textsuperscript{(125)} It could therefore be argued that Chevaline does not amount to an egregious example of vertical proliferation. A move consistent with this would have been a decision to acquire the Poseidon SLBM from the US. Indeed acquisition of Poseidon was seriously considered in the 1970s, but rejected ostensibly for political reasons.\textsuperscript{(126)} A more plausible reason for rejection of Poseidon at that time is connected to the state of US third generation SLBM R&D. In short, it would make greater strategic sense to wait for the Underwater Long Range Missile System, Trident, on which work had been under way in the US since 1967.

The budget and engineering problems of the Chevaline programme proved to be major factors in the eventual decision on "Wholesale" Polaris replacement.\textsuperscript{(127)} Although Chevaline received US assistance, it was essentially an independent programme.\textsuperscript{(128)} If anything Chevaline
demonstrated the pitfalls of pursuing independent programmes on delivery systems. Resolution of the Polaris renewal question in favour of the US Trident C-4 system, which was publicly announced in July 1980, had the advantages of the Polaris project and disadvantages of Chevaline very much in mind. Commonality with the US was the key to the decision. With the second NPT Review Conference due in September it is clear that the British government did not consider Trident inconsistent with Britain's NPT commitments. In addition, as the thermo-nuclear decision had made clear, with Britain already a weapon state it did not make sense to "forgo the benefits of the most up-to-date weapons". Such action was unlikely to undermine Britain's ability to prevent the proliferation of nuclear weapons.

12. TRIDENT

Polaris replacement was a problem for the Labour governments of 1974-1979. Nonetheless studies were carried out on possible Polaris replacements.\(^{129}\) In 1976 a decision was taken to build a tritium separation plant at Chapel-cross to provide an indigenous source of thermonuclear fuel for the long term.\(^{130}\) This would suggest some commitment to a Polaris replacement as it made little sense to make such a major investment if the intention was to abandon the deterrent. In the event the replacement decision fell to the Conservative government elected in May 1979. Once the cruise missile option had been rejected, there was only one system that appeared to make economic and strategic sense - Trident C4. This represents yet another quantitative and qualitative increment to Britain's nuclear capability.

The Trident C4 SLM is qualitatively superior to Polaris and Poseidon. It has a range of 4000 nautical miles, but with an improved accuracy. Trident C4 SLMs deployed by the US Navy are armed with 8 W76 100 kt warheads. However, even before the deployment of C4 it was clear in the US
that the Trident D-5 system would be far superior. The throw-weight is, for example, double that of Trident 1 at 6000 lbs and is thus capable of carrying 10-15 re-entry vehicles. (131) Once the Americans had decided to switch to the D-5 system, the British had to follow suit as the advantages of commonality would be annulled and the Royal Navy would become saddled with a redundant missile system. As the MOD Defence Open Government Document of March 1982 stated, the principal reason for the switch to D-5 was precisely this need to maintain commonality with the US. (132) There are major advantages to be gained from commonality; for instance, it was a missile motor failure shown up in the US missiles which led directly to the remotoring of the British Polaris missiles. (133) Thus for logistical, economic and technological reasons the British were locked into a further expansion of their deterrent force. Doctrinal imperatives, (nuclear weapons are fundamental to British military security) precluded abandonment of the deterrent.

The Trident decision represents a substantial increase in the number of deliverable warheads in the British stockpile. As with the Polaris SSBN fleet four submarines were planned, each one with sixteen missile tubes. It was announced, "that the move to Trident D-5 will not involve any significant changes in the planned total number of warheads with our strategic deterrent force in comparison with the original intentions for a force based on the C-4 missile system." (134) Thus assuming 8 warheads per missile and 16 D-5 SLBMs per submarine, the complete force will require 512 warheads at least. However, a more conservative estimate puts the number at 384. (135) As noted above the most likely total of warheads in the British inventory is in the 577-700 range, and even allowing for the withdrawal of the Polaris warheads, the Trident programme, cannot be regarded as anything other than a substantial increase in the number of deliverable warheads. It should also be noted that more than half of the RAF's front-line
squadrons are nuclear capable. (136) In short, the NPT notwithstanding, the British nuclear stockpile for the 1980s and 1990s is set to expand quantitatively and, crucially, qualitatively. As was made clear at the 1980 NPT Review Conference the British saw no contradiction between the objectives of the NPT and British nuclear defence policy. Both the 1954 thermonuclear decision and the negotiating record of the NPT itself demonstrates the continuity in British attitudes to the relationship between British nuclear weapons and vertical proliferation.

13. CONCLUSION

In this discussion of British nuclear weapons development it is difficult to separate political rationales from the technological pressures. Is it doctrine that drives technology or technology that drives doctrine? The British case seems to suggest neither; rather, there are elements of both in the key stages of the British nuclear weapons programme since 1947. The 1954 thermonuclear decision is perhaps the best example, and certainly the key decision as far as proliferation implications are concerned. Doctrinal and technological factors were involved. On one level possession of thermonuclear weapons was regarded as vital to the security of the state; however, the Cabinet in one sense was merely asked to endorse preliminary work already under way. Nuclear weapons have been regarded as fundamental to British military security, but technological factors have severely restricted options as the Trident decision demonstrates. One factor has remained constant however. Successive British governments have regarded the British nuclear weapons programme as having no bearing on nuclear proliferation. The same thinking has persisted through to the Trident decision. Despite this the British weapons programme itself has shaped attitudes to the proliferation problem. Specifically, statements made on the nature of the civil-military relationship and the ability of industrialised states to produce their own
nuclear weapons irrespective of the actions of others, are rooted in Britain's own experience. Having rejected in practice the relationship between vertical and horizontal proliferation, British non-proliferation policies have in reality concentrated on the civil-military relationship. Proliferation is defined in horizontal terms.
CHAPTER 4


1. INTRODUCTION

The fundamental technical connection between the civil and military uses of nuclear technology and materials makes their export a particularly hazardous policy assuming a commitment to non-proliferation. There is a fundamental dilemma between, on the one hand, a desire to prevent the emergence of additional nuclear weapon states, and on the other with a wish to establish a successful export market. At one level it is arguable that these two courses are diametrically opposed. Alternatively the pursuit of both objectives simultaneously undermines their likely individual success. For example, whilst the Foreign and Commonwealth Office might favour a more restrictive export policy, the Department of Trade and Industry, the National Nuclear Corporation and British Nuclear Fuels might prefer a liberal export policy. Thus the extent to which the British have managed to balance these two objectives, commercial and non-proliferation, since 1952 may be considered as an essential element in the shaping of British attitudes to nuclear proliferation. Conversely, the pursuit of one objective may have been at the expense of the other. It is the purpose of this and subsequent chapters (5,6) to ascertain which of these outcomes best describes British policies.

For the purposes of this chapter nuclear exports may be divided into three principal categories: nuclear power reactors and research reactors; fuel and fuel cycle services such as fabrication, conversion, enrichment and reprocessing; and exchange of nuclear expertise and information through co-operative and collaborative agreements. There is also a fourth area, non-nuclear "conventional" technology and materials. This will not be discussed separately here, but reference will be made to
the problem in chapter 6. Furthermore British nuclear export history may be divided into broadly three chronological periods. These are largely determined by organisational and structural changes in the nuclear industry; reactor choice decisions; and by the modernisations and expansion of fuel cycle facilities. These divisions are admittedly somewhat arbitrary since decisions taken in one period do not assume concrete form until well into subsequent periods. The purpose here is to compare export policy with the emergence of the international non-proliferation regime, and see whether there is any continuity in British policies and objectives.

British civil nuclear history may be divided into three periods. These are: 1954-1965 which covers the formation of the United Kingdom Atomic Energy Authority (UKAEA) through to the Second Nuclear Power Programme and the decision to opt for the British designed Advanced Gas Cooled Reactor (AGR) as the reactor for that programme. 1965-1971 covers several key developments including the major organisational changes to the UKAEA and the industrial consortia. The most significant of these, arguably, was the hiving-off of the UKAEA's Production Group, which was responsible for the fuel cycle services, to form British Nuclear Fuels Limited (BNFL). In addition, Britain, the Federal Republic of Germany and the Netherlands concluded a collaborative treaty establishing a tripartite organisation to provide enriched uranium. In the third period, 1971 to 1982, the activities of BNFL expanded. The Windscale Inquiry in 1977 was perhaps the most important event in relation to export policy and non-proliferation. Moreover, the delays in the AGR programme and continuing dispute over reactor choice for the Third Nuclear Power Programme had a major bearing on UK reactor export prospects.
2. ORIGINS OF EXPORT POLICY and REACTOR EXPORT 1954-1965

The technical origins of civil nuclear power in Britain are to be found in the military programme.\(^{(1)}\) Between 1945 and 1952 several key decisions were taken which decisively influenced the course of British nuclear reactor policy. These were to have special bearing on the success of British reactor exports in subsequent years. For both technical and financial reasons Britain opted for air-cooled reactors for the military programme.\(^{(2)}\) The two plutonium producing reactors at Windscale were the forerunners of both the Magnox and AGR systems developed in the 1950s.

As early as 1941 the Maud Committee, established to examine the feasibility of a "uranium bomb", took advice from ICI. In an Appendix to the Final Report ICI argued that:

> It is essential that Great Britain should take an active part in the research work so that the British Empire cannot be excluded by default from future developments.\(^{(3)}\)

The desirability of exports is implicit here. Although the provisions of the wartime Quebec Agreement explicitly precluded the British from taking "any post-war advantage of any industrial or commercial character", this in practice did not matter immediately since the military programme took precedence until 1952.\(^{(4)}\) Moreover, the US Atomic Energy Act of 1946 dissolved the "special relationship" which had characterised wartime Anglo-American nuclear co-operation. The 1946 Act although described as the first non-proliferation strategy, only served to stimulate the expansion of an independent British nuclear programme.\(^{(5)}\) The independence apparent in the military programme was inherited by the civil programme. After the successful completion of the weapons programme in
October 1952 more attention was given to the civil uses of nuclear technology. Two objectives were quickly established for the civil programme: generation of reliable supplies of electricity and creation of a nuclear export trade. (6)

3. THE TREND REPORT AND THE FIRST NUCLEAR POWER PROGRAMME

In 1954 responsibility for the atomic energy programme was transferred from the Ministry of Supply to the newly established UKAEA. (7) Between 1952 and 1954 discussions at Cabinet level and within the Ministry of Supply were held on the future shape of the atomic energy project. In 1954 an inter-departmental study was commissioned to examine the feasibility of nuclear power for civil purposes. Under the chairmanship of a Treasury official, Burke Trend, a report was produced entitled The Production Of Power From Nuclear Energy. This formed the basis of the First Nuclear Power Programme announced in February 1955. The Trend Report, as it was known, outlined the export implications of nuclear power development in the UK. It is worth reproducing in full the relevant section on exports because it is remarkable for its complete lack of consideration of the security implications of nuclear exports. This is even more surprising since the original version of the report contained "a small amount of material which was of military significance." (8) Paragraph 186 was devoted to exports, it noted that:

If such developments as we have described above were possible in this country, they would also be possible elsewhere, and if we may assume that competitive nuclear power stations became practicable in the UK, where conventional power is cheaper than in many areas, the world demand for nuclear technology, for the building of nuclear power stations and for the processing of nuclear material, would appear to be,
in the long run immeasurable. This hypothesis has important implications for this country. Provided that industrial effort were enlisted and trained sufficiently early and extensively we could be comparatively well placed to supply some of this demand; and indeed, the exports which we achieved would probably be limited solely by what we made ourselves capable of supplying. This consideration is particularly relevant in the case of plutonium since an expanding world demand for power would also imply an increasing demand for plutonium; and if the the UK programme expanded sufficiently quickly and produced supplies of plutonium in excess of those needed for the further expansion at home, we could afford to export the surplus. The value of such exports would lie not only in the foreign exchange which they earned; since they could be produced (by the use of suitable fuel cycles) as a by product of electricity generation, their sale at world prices would effectively reduce the cost of domestic electricity. But it should always be remembered that the establishment of an export trade in plutonium would depend essentially on the initial expansion of our own domestic programme being sufficiently rapid and extensive.(9)

Moreover, the Report noted that in view "of the potential export market for nuclear products and techniques which is already beginning to emerge, there should be no avoidable delay in enabling industry in this country to acquire experience of the practical application of nuclear energy on a commercial scale."(10) Thus export considerations played a major role in the origins of the first nuclear programme. Although it should be noted that the domestic programme took priority.

The UK industry, in short, was not export led.
The Cabinet approved the first nuclear power programme because of its potential importance for domestic energy policy. In a memo submitted to the full Cabinet on 15 December 1954 The Production of Power From Nuclear Energy, one of the objectives of the programme was made clear:

It is important to embark on a civil programme now in order to ensure that this country is in the forefront of the development of this technology. In addition to the economic advantages of the fuel situation at home, there would be the commercial advantage of putting our engineering consultants and industry in the position to sell abroad power reactors and the associated plant, equipment, materials and technology, and there would clearly be a political advantage in being first in the field, which would enhance our influence in both foreign and Commonwealth countries.\(^\text{[1]}\)

In February 1955 A Programme Of Nuclear Power was published.\(^\text{[12]}\) Construction of twelve reactors over a ten year period was proposed, but that was not all. As both the Trend Report and Cabinet memo recommended:

We must look forward also to the time when a valuable export trade can be built up. The experience gained by British industry in designing and building nuclear power stations during the next ten years should lay the foundations for a rapid expansion both at home and overseas.\(^\text{[13]}\)

Five industrial consortia were established to compete for the tenders of the power programme. However, organisationally the industrial structure was a disaster for both the domestic and export markets. Indeed there was very nearly a sixth consortium. There is little publicly available evidence from this period suggesting that nuclear power reactors ought not to be exported on account of the
proliferation risk. It is also important to note that there was no international safeguards system in existence in the mid 1950s. Moreover, safeguards technology was virtually non-existent. Despite this the British sought to promote nuclear exports before an adequate safeguards system existed. British officials appear to have been confident that security would not be compromised by reactor exports. However, it should be pointed out that large scale sales of power reactors did not occur until after 1965 by which time a safeguards regime was beginning to emerge. From the outset there was never any question that nuclear technology should not, in principle, be exported.

4. ATOMS FOR PEACE: THE BRITISH RESPONSE

The Atoms for Peace proposals outlined by President Eisenhower at the UN General Assembly in December 1953 represented a radical break from US post-war nuclear policy. The technology denial of the MacMahon Act had failed; moreover, it had encouraged independent programmes in Canada and the UK. Non-proliferation could now be best ensured by making the benefits of civil nuclear power available to overseas states, especially those in the developing world. Before making his speech Eisenhower had consulted Churchill and Lord Cherwell at the 1953 Bermuda Conference. The British endorsed the principles underlying the Atoms for Peace concept. Indeed the principal reason for British support was based on self-interest. Liberalisation of the nuclear regime would enable the British themselves to have greater access to American information. However, whilst accepting the basic principles, the British harboured doubts about the specifics of Eisenhower's Plan. In addition the British response in 1954 reveals a great deal about British thinking on the civil-military relationship and nuclear exports. For the purposes of this study five British concerns are of particular relevance: basic support for the principle; necessity of Soviet participation; suspicion of proposed
international agency as inimical to British interests; need to protect increased co-operation and contact with Commonwealth and Europe; and finally security aspects.

The British knew 6 to 8 months prior to Eisenhower's speech that the US government had given thought to the possibility of liberalising their policy towards the exchange of atomic information. Nevertheless, it was not until the Bermuda Conference that the British learned of Eisenhower's intentions. The actual speech itself contained four points on an International Atomic Energy Agency which were added hastily to the speech. But it appears that the full implications of the plan were not worked out in advance.

Sir Roger Makins, British Ambassador in Washington pointed out that this would enable the British to suggest the lines along which the Plan could be developed. Consequently the Atomic Energy (Official) Committee considered what functions the new Agency might have. Indeed this is what happened since the eventual text of the IAEA's statute contained a great deal of British language.

One of the central ideas of the AE(0)C was for an international depository of nuclear fuel; natural uranium and fissile material. Given the pressures on fissile material production in the UK any British contribution would have to be small. It was also proposed that the IAEA should be a research agency offering advice and technical assistance on national atomic energy projects. It could also be a Production Agency which would decide on the best method of using the potential power for the development of other countries. Soviet participation in the system was considered vital:

United Kingdom participation in a plan which did not include the Russians would entail considerable economic and other disadvantages to this country and would cut across the policy of developing co-
Indeed the AE(0)C recommended that Makins should be instructed to discourage the Americans from proceeding with Eisenhower's plan if the Soviet government refused to participate.(20) The British were concerned that the specifics of the Eisenhower plan would entail a diversion of part of the domestic atomic effort and materials which, although small, could not really be spared. It was also feared that the US, "through her much larger contribution to the IAEA, would dominate the atomic projects of the free world, including those in the Commonwealth countries, and thereby secure economic advantages in the coming competition for orders for the construction of atomic plants."(21) Despite these reservations the British were prepared to support the Plan, "as a price worth paying to secure a relaxation of international tension." Without Soviet participation "national interests" required that the plan be dropped altogether.(22) Moreover British:

interest lies in continuing to develop our own atomic co-operation with Commonwealth countries in accordance with the Cabinet's decision of April 21, 1953 (C.C. (53)) 28th conclusions item 5, and with other countries (particularly in Europe) as opportunity occurs.(23)

In short this appears to have been the principal British reservation; that is, it would be "to the detriment of our position in the Commonwealth and in the overseas markets."(24) The British had therefore no objection to the principle of a liberalised nuclear regime, nor to the export of nuclear reactors, on non-proliferation grounds. It was hoped that British industry would be in a position to capture a significant percentage of the world-wide demand for reactors. The Commonwealth countries figured...
in these calculations. During British consultations with the US over Eisenhower's plan, it was decided to keep the key Commonwealth countries, Canada, Australia and South Africa abreast of British thinking. The latter two's role as major suppliers of uranium was crucial. The proliferation dangers of the proposed IAEA and liberalising the exchange of nuclear information were not considered sufficient reason to oppose the principles underlying Atoms for Peace. This is clear from the AE(O) Committee's Report. It was envisaged that the research agency might go on "to build experimental reactors, using natural uranium and possibly breeders using fissile material" for national programmes. Provision of fuel would also be one of the agency's functions. Although this material would have to be accounted for, as would all fissile material produced by plants erected by the Agency, inspection which on political grounds would be quite impractical, would not be so important. Thus in the early years the British did not consider a "safeguards" inspection system necessary because:

there is a close ascertainable relationship between the type of atomic pile, the quantity of uranium or fissile material used, and the power output on the one hand, and plutonium production on the other; this should in itself provide for adequately strict control. Moreover, there are serious practical difficulties in clandestine recovery or surreptitious diversion of plutonium away from atomic energy plants and it would not be easy for any inexperienced country to do this, with the important exception of Soviet satellite countries contiguous to the USSR. (26)

Implicit here is the assumption that a state wishing to embark on a militarily significant nuclear programme would not choose "clandestine recovery or surreptitious diversion of plutonium away from atomic energy plants". This standpoint has remained fundamental to British attitudes to
proliferation. However, this assumption seems a shade disingenuous in light of information available to the British as early as October, 1953.

Paragraph 15 of the Committee's Report refers to American theories about the possibility of denaturing uranium so as to render it incapable of being used for nuclear weapons while not impairing its production of power. The Committee felt that this theory had no validity, but since the basis for this assessment rested on "Top Secret information which it is possible that the Americans do not possess", it was not communicated to the Americans. (27) It is not immediately clear what this information was; however, in a minute from the Foreign Secretary to the Prime Minister of 20 January 1954 all becomes clear:

You may be interested to know that it is as a result of one of Penney's experiments in Australia last October that our experts reject the American theory mentioned recently in the Times that uranium can be made useless for bombs while remaining suitable for peaceful purposes. (28)

It seems reasonable to assume that these references refer the the Totem tests of 15 and 27 October 1953. As noted in chapter 3 Penney's experiments were designed to see whether plutonium containing a higher percentage of Pu-240 than normal, as would be contained in fuel rods with a high burn-up necessary for power generation, would explode. These experiments were successful. Consequently it is clear that the British were aware, at the highest level, that there were no technical solutions which would prevent use of nuclear material for military purposes.

In the event the Soviet Union agreed to join the IAEA, but it took a further four years before the Agency came into existence. For the British the basic principles of Atoms for Peace were acceptable; indeed, the Cabinet had decided
before Eisenhower's December 1953 speech to develop British nuclear co-operation with Commonwealth and European countries in the hope, presumably, that this would lead to future reactor orders.
5. THE CONSORTIA AND POWER REACTOR EXPORTS

Organizationally responsibility for power reactor exports lay with the industrial consortia(29); however, the UKAEA had a direct interest. The Third Annual Report declared that the Authority was "closely involved" for three reasons:

First the Calder Hall type of reactor is the only type of power reactor of British design at present available for exports from the UK. As its designers and operators, the Authority are well qualified to describe its features and advantages to potential customers. Second, it will be the responsibility of the Authority to supply the fuel elements for reactors of British design exported by industry. Third, the Authority have a part to play in the intergovernmental negotiations which are necessary before reactors or fuel elements may be supplied to other countries.(30)

However, because PIPPA, the Calder Hall reactor design was authorised as part of the military programme the British Electricity Authority (BEA) were not permitted to own or operate the reactor.(31)

It was thought that Italy would be the ideal reactor market because Italy had the most expensive electricity in West Europe in the 1950s.(32) Britain and the US were then the only two possible suppliers of power reactors. There was intense competition between the two. A widespread international interest in the British nuclear programme was engendered when the UKAEA opened the first two Calder Hall reactors in October, 1956. Calder Hall gave the impression that the British were technically ahead of the Americans. Indeed there were fears in the US that the British had the potential to corner the nuclear reactor market at the expense of American constructors.(33) This was not lost on
the British either.

As it transpired a British consortium won the contract to build Italy's first nuclear power station at Latina. This was ordered by the Italian state energy company at the height of the Suez crisis.\(^{(34)}\) Construction started in 1958. Latina's Magnox reactor was designed by the Nuclear Power Group. It was supplied with natural uranium fuel elements made at Springfields by the UKAEA's Production Group.\(^{(35)}\) Latina was Europe's first full-scale nuclear power-plant when it went into operation in 1964.\(^{(36)}\) The only other reactor export at this time was secured in 1959 by the GEC-Simon Carves Consortium. An order was placed by the Japanese Atomic Power Company for 2 Magnox reactors of 159MW(e) to be built at Tokai Mura. It was not completed until 1966. The proliferation risks associated with nuclear exports can be established from an assessment of Japanese nuclear capability published in 1975:

> Of all the Japanese reactors, the one most suited to quick conversion to the production of military-grade Pu-239 is the Japan Atomic Power Company's Reactor No. 1 at Tokai Mura.\(^{(37)}\)

But as we have seen the British Governments of the 1950s did not consider this a likely possibility. It should be noted that both Italian and Japanese reactor sales agreements were subject to safeguards agreements. Latina, for example, was subject to Euratom safeguards whereas Tokai Mura was safeguarded by a bilateral government agreement. It was not until 15 October 1968 that the safeguards provisions for Tokai were transferred to the IAEA.\(^{(38)}\) Nonetheless the recovered plutonium from the spent fuel elements remained the property of the Italians and Japanese.
Despite these early successes there was no guarantee that subsequent power reactor exports would inevitably follow. A key factor would be the competitiveness of nuclear power stations with their conventionally fuelled counter-parts. In November 1955 a high level meeting involving leading individuals from the UKAEA, the engineering and electricity industries considered the export prospects. Amongst the observations and conclusions it was noted that:

industry would best improve its prospects of future export business by concentrating immediate effort on making a success of the UK nuclear programme.

In 1956 the UKAEA maintained a sober view on export prospects:

it is hardly to be expected that exports of nuclear reactors will reach a large volume over the next few years. There is already some demand from overseas countries for research reactors, but not at such magnitude as to affect significantly the total value of the engineering industries annual exports. As to power reactors, it will be at least four or five years before electricity will be provided from nuclear energy in any country on a strictly commercial basis. The first nuclear reactors to be built for the electricity authorities in this country may be the first in the world to comply with this description. It is reasonable to expect that orders will follow, rather than precede, the achievement of nuclear power on a competitive basis in this country.

It was clear to the UKAEA that competitive nuclear power in Britain would result in increased overseas reactor sales. Therefore, the success of the first nuclear power programme was crucial. Claude Gibb reported to Sir Edwin Plowden that exports should only follow the successful operation of
prototype reactors in the UK. Moreover, after discussions with "senior and responsible" members of overseas electricity undertakings, Gibb noted that the views expressed universally have been that they would prefer to sit back and await the technical and economic results from British nuclear power stations. (42) Central to commercial generation of electricity would be the performance of the nuclear fuel. Ideally the fuel elements should be left in the reactor for much longer periods than those required for a military fuel cycle, where short irradiations of about four months were ideal. However, at this time the UKAEA had no experience with fuel irradiated beyond 1000 Mwd/te. For economic generation of electricity much higher burn-ups were required; the first Magnox fuel elements were designed for 3000 MWD/te.

Plowden made several key observations when he summarised the November, 1955 meeting. There was unlikely to be a large demand in the long-term for reactors of 30 MW and under; that the direction of the export trade was likely to lie in the supply of the larger type of reactors, and that the UKAEA would be able to supply the fuel and processing facilities required to meet the estimated demand of this trade when it began. Plowden concluded, significantly from the proliferation perspective, that plutonium was likely to be available in the middle 1960s, and could be used either at home or for export, according to the circumstances which existed at the time. (43)

From the tenor of the conclusions it is clear that security considerations should not unnecessarily obstruct nuclear exports. However, availability of fissile material, U-235 especially, was limited since the military programme took precedence. This constrained export opportunities for research reactors. Furthermore, the UKAEA was actively engaged in helping British industry acquire the necessary knowledge for it to compete in export markets for nuclear power stations. (44) Although there were considerable
demands on the UKAEA's resources, it nonetheless did "everything possible to help industry to equip itself to do business in the atomic energy field and, while exports are not to be of major importance in the immediate future, UK industry is being given every possible assistance to prepare itself to take part in what may well become an export trade vital to this country".

Plowden, however, did not think it advisable to install nuclear power plants in underdeveloped countries. There was neither the infrastructure or finance for such projects. Western Europe was another matter. The main focus was the OEEC. W. Strath, a UKAEA official noted that, "it was worth bearing in mind that countries in Western Europe who were faced with similar power difficulties to ours might well be attracted by solutions which we had evolved and which did not depend for their fuel on supplies from a US source." (45) This consideration was to prove central to subsequent non-proliferation policy (see chapters 11, 12). Since nuclear power was thought to offer advantages in terms of energy security it was better to satisfy states' legitimate interests by making the benefits of the peaceful atom widely available. Unreliable energy supplies, instability and unpredictability in the fuel market were more likely to undermine the international non-proliferation regime. (46)

Despite identifying the OEEC as the most likely export market, English Electric were more circumspect. They observed that Western European states, Italy, France, FRG and Switzerland in particular possessed well developed manufacturing resources which were underdeployed. This could limit export prospects for British companies. Moreover, many of the components of a power reactor were similar to those involved in an ordinary steam power station. Consequently English Electric were, "inclined to the view that the effort of all British manufacturers should be directed towards the export fields of the
Commonwealth countries and other less industrialised territories as a first priority after the UK White Paper Programme."(47) This attitude was an important factor in the failure of British industry to export more than two nuclear power stations. For many of the engineering companies "imperial preference" was considered a positive advantage in the markets of the former Empire and now Commonwealth countries.(48) This did not materialize.

The export of power reactors was a major objective for both the UKAEA and consortia. Neither appear to have taken the view that nuclear reactors should not be exported on security or non-proliferation grounds. These considerations were not completely ignored. The Foreign Office maintained a close watch on nuclear exports. Indeed a licence was required under the Export of Goods (Control) Orders, statutory instruments issued under the Import, Export and Customs Powers (Defence) Act 1939. Between 1955 and 1958 responsibility for nuclear energy in the FO came under the purview of the Permanent Under-Secretary's Department, and from 1959 until 1968 under the Atomic Energy and Disarmament Department.(49) Indeed such was the level of Government involvement that one of the leading British nuclear trade journals considered such control as an obstacle to further trade:

While the British government with one voice is exhorting industry to increase its export effort, it should with the other be doing its best to prevent any such export occurring. We refer to the continued refusal of the Government to waive its demand for inspection of an overseas reactor exported from the country, either directly by UK representatives or through the IAEA.(50)

Whilst it is true that the UK managed to sell only three power reactors in this period, it cannot plausibly be maintained that over-concern with safeguards and non-
proliferation was the major contributory reason for this.

Other factors such as the structure of the industry and the availability of US LEU were much more important. The latter can be seen from the export of British research reactors.

6. RESEARCH REACTORS

J. Jukes, Economic Adviser to the UKAEA between 1954 and 1964, noted in 1956 that:

There will probably be a market for research reactors and equipment: this may not be large in absolute terms but it will be important in that it will build up connections and open the way for bigger markets in later years. (51)

It was largely through the medium of research reactors provided under the Atoms for Peace Programme that US companies were able to secure in the 1960s and 1970s the largest share of the power reactor market. Research reactors and guaranteed cheap supplies of LEU and HEU were, as the UKAEA itself realised, crucial. The UKAEA, however, was hard pressed to compete because the research reactor designs it had available for export depended on HEU and the Production Group's output of HEU was limited. Security considerations were also evident. These posed difficulties. In April 1956 Jukes wrote that:

At present the UK is unable to offer a high-flux materials testing reactor for general sale abroad because both DIDO and PLUTO were designed to operate on material of 90% enrichment and we have agreed with the Americans to limit the concentration of material supplied abroad to 20% for security reasons. (52)

Despite this observation the same report went on to estimate the possible market for UK high flux research
reactors of the DIDO or PLUTO type in the years up to 1964. A potential overseas market was expected for about 8 reactors, including one already sold to Australia and the one under negotiation with Denmark.(53) If, however, the US could be persuaded to waive the 20% rule for DIDO reactors, "it will be possible to offer new reactors with a performance substantially similar to that of DIDO". This course of action, it was assumed, would lead to the sale of a few more DIDO reactors. Several other options were considered all of which would increase the export attractiveness of British research reactors. The conclusions outlined one possible course of action:

A decision is required whether we should approach the US with a view to obtaining their agreement for the use of 50% material in export reactors.(54)

Since the UKAEA did not have the resources to design and produce another materials testing reactor (MTR), this option had attractions. However, the US position was such that any change was unlikely to have any impact. For instance,

The MTRs burn U-235 either as highly enriched alloy or 20% oxide, and appear to be sufficiently, under-moderated for the same quantity of U-235 to be needed at either enrichment. The USA is therefore in the fortunate position of being able to impose a 20% U-235 limit, without affecting either her design or export status. With at least 4 years lead over the UK in this field, and several excellent designs... her position is strong indeed.(55)

It is thus clear that the UKAEA was prepared to lower security requirements in order to expand export opportunities for research reactors. However, it is not clear whether such steps were ever taken. The ultimate decision would have rested with Government, and not the UKAEA.
Nevertheless even in relation to research reactors, which are as much a proliferation risk in terms of fissile material and experience gained from their use as power reactors, non-proliferation objectives were not considered important enough to preclude exports.

Even though the prospects of extensive research reactors exports were slim exports were more than a matter of a contribution to the balance of payments. Indeed it was noted that the monetary returns for research reactors and their associated equipment would be very small. A paper submitted to the Jukes Working Party on Research Reactors outlined the real significance of exports:

The UK has indicated that she is in a position to export satisfactory high flux research reactors to several countries. To have to withdraw this statement and advise them to purchase American equipment would be most undesirable.\(^{(56)}\) \(^{(57)}\),\(^{(58)}\)

7. FUEL CYCLE SERVICES 1954 - 1965

Regardless of reactor type each system requires an initial fuel load as well as subsequent re-loads. This fuel must first of all be processed. For example, fuel is fabricated into a suitable form for use in a reactor, usually in the form of pellets which are filled into a fuel pin. These are then assembled into bundles of various sizes depending on reactor type. Magnox reactors, such as those exported to Italy and Japan are fuelled by natural uranium. The Latina and Tokai Mura reactors required 290 and 200 tonnes of natural uranium fuel respectively.\(^{(59)}\) The UKAEA Production Group provided both the initial fuel loads for these reactors and has reprocessed all subsequent spent fuel. By 1965 the UKAEA remarked that, "the scale of commercial effort overseas was considerably increased during the year and important contracts were secured including a contract for the reprocessing of irradiated
fuel from the Latina station in Italy."(60)

An internal UKAEA report remarked that, "at a suitable time in the development of the atomic energy programme in Italy, the UKAEA are prepared to assist in setting up fuel fabrication and reprocessing plants either by negotiation with a government body or by licensing arrangements with an industrial concern to build and operate a suitable plant."(61) Within the Production Group there was a growing commercialism represented by a desire to expand the scale of operations. In March 1957 Dr. J.M. Hill, later Authority Chairman and Chairman of the Production Group's successor BNFL, argued that:

It is clear that with the development of the atomic energy industries in other countries there are going to be increasing demands for the construction of chemical plants in these countries, even though in the early stages of the programme from a strictly economic point of view it would probably be preferable for them to have their processing done in UK plants. In these circumstances we clearly wish to obtain as much of this business for the UK as possible, and we must be prepared either to undertake this work within the industrial group or put British industry in the position where they could undertake this work, if necessary with assistance from the Authority.(62)

Christopher Hinton, Board Member for Engineering and Production, took the view that the UKAEA ought not to make a general practice of designing and supplying chemical plants to atomic energy interests overseas.(63) Since only two years previously the UKAEA had been prepared to supply a diffusion plant to France(64), commercial rather than proliferation concerns may have been foremost in Hinton's mind. It would be better for the UKAEA to provide overseas customers with reprocessing services.
The agreement signed with Japan in June 1958 made similar provision for fuel services. However, Japan was permitted to retain the recovered plutonium for peaceful purposes. Moreover, the UKAEA also offered to provide any technical assistance required to build fuel manufacturing and reprocessing plants in Japan. In short, provision of fuel services was considered to be a vital element in a successful export policy. (65)

The military programme placed the UKAEA in an ideal position to offer fuel services since plants for all parts of the fuel cycle already existed: Springfields, conversion and fabrication, Capenhurst, enrichment; Windscale, reprocessing. From the mid 1950s until 1964 these plants served a dual purpose until military production ceased, but some military work continued to be done at these plants. Windscale was subsequently adapted so that it could reprocess oxide fuel from overseas. (66) But even in 1965 the European nuclear industry was still in its infancy. This was to change and as the nuclear power programmes expanded so too did British nuclear fuel services. (67)

In 1963 the UKAEA supplied the French Atomic Energy Commission (CEA) with 45 kgs of plutonium oxide for the experimental fuel reactor Rapsodie. (68) The quantity required to fuel Rapsodie was roughly equivalent to a whole year's output from one of France's two plutonium producing reactors. In fact the plutonium producing reactors at Marcoule were estimated to have an annual output of 100 kgs. This explains why the French, with their military requirements, could not spare indigenously produced plutonium. (69) Although Britain did not make a direct material contribution to the French weapons programme, the provision of plutonium for research purposes permitted the CEA to maintain both an advanced civil and military research and development programme. (70) Since there was a plutonium production problem in France which could not
satisfy the needs of both civil and military programme, British assistance did make a significant contribution to the establishment of nuclear power in France.\(^{(71)}\)

Bertrand Goldschmidt, a key individual in the CEA, reveals that the UKAEA was prepared to supply more than just nuclear fuel. In 1954 the CEA approached the UKAEA to see if it would be prepared to construct a gaseous diffusion plant, similar to the Production Group’s Capenhurst plant.\(^{(72)}\) Both Sir Edwin Flowden and Sir John Cockcroft were keen on the idea and provided Goldschmidt and Guillaumat with details of various sized units, construction time and electrical consumption. However, the negotiations were curtailed in February 1955 because of US pressure. The Americans cited the Quebec Agreement which prevented the British disclosing technical details derived from the Manhattan Project to third parties. Despite this, both Sir John Hill and Dr Ned Franklin argue that the Americans could not have prevented such a deal on the grounds that American secrets would be compromised.\(^{(73)}\) On the contrary, the Capenhurst gaseous diffusion plant was first to last an exclusively British project. Instead British government doubts about the wisdom of such a transaction, arguably for fear of antagonising the US and thus jeopardising Anglo-American nuclear co-operation, foreclosed the deal, UKAEA enthusiasm notwithstanding. The French, however, were able to master the technology and built their own plant at Pierrelatte.\(^{(74)}\) British denial of assistance in 1955 merely delayed the event.

The UKAEA had a clearly defined objective with regard to the provision of fuel services. In the Second Annual Report 1955 - 56 it was noted that:

\[
\text{such surplus capacity as the UK may have for fuel element fabrication and chemical processing will at all times be made available to such other of the other OEEC countries as may wish to avail themselves}\]

This policy was unaltered eight years later. In October, 1962 Sir Leonard Oven, who was then UKAEA Board Member for Production and Engineering, stated that all the UKAEA's fuel processing, fabricating and reprocessing facilities, including Capenhurst were to be made available to customers in the European countries. Indeed the Production Group commissioned an advertising campaign in European technical journals to this end.

By 1965 the Production Group was able to quote competitive prices for fuel cycle services throughout the world. Indeed the "scale of effort" overseas was considerably increased during 1964-65. At the Third UN Conference on the Peaceful Uses of Atomic Energy in 1964 it was stated by UKAEA representatives that the "total quantity of money involved internationally in the nuclear fuel cycle is currently of the order of £100 million each year. It was forecast that given current rates of power plant construction, the annual turnover within thirteen years could be several thousand million." The Production Group was not unaware of this situation and hoped to secure a sizeable share of the business.

Within the Authority, the Production Group especially, there were ready reasons for the expansion of the export business. These were in part related to the downturn in production of fissile material for military purposes. Production reached a peak in 1959-60, but it ended in 1964. Work had to be found for the excess capacity of the plants since the Production Group Managers of the day decided that they could not live on the domestic market alone. Indeed Sir John Hill noted that the group nearly collapsed because of the cutback in defence production.
The history of the Capenhurst gaseous diffusion plant is illustrative of the export orientation of British nuclear policy. Capenhurst was originally built to provide enriched uranium for the weapons programme. Construction of a gaseous diffusion plant to enrich fuel for the Windscale Piles began in 1949 and was completed in 1952. The plant was extended in the late 1950s to accommodate the increased demand for highly enriched uranium (HEU) for the thermonuclear project; this work was finished in November, 1959. By the end of 1962, however, HEU production was halted. The subsequent running down of the plant, the high diffusion stages were mothballed, did not escape attention. Gerald Nabarro MP feared that "the run down ... may well undermine our competitive power for supplying western Europe with enriched uranium fuel as their nuclear power programmes develop for civil use." In the end work for Capenhurst did increase. Capenhurst was modernised to provide LEU for the Second Nuclear Power Programme launched in 1965. LEU was now required as the reactor choice, the AGR, burned enriched fuel unlike its natural uranium predecessor. Although the principal reason for the plant's reactivation was to furnish the domestic programme, export considerations played their part. Frank Cousins, then Minister of Technology, stated that one of the reasons for the modernisation was precisely the existence of export possibilities both for enriched uranium and reactors. If AGRs were to be exported a national source of LEU would enhance prospects. Moreover, the UK was reluctant to depend on the US for fuel for the power programme. The relationship between fuel dependency and non-proliferation strategy was to become much more pointed in the 1970s. By 1965, however, the basis of the future expansion of the fuel service export was well established. Subsequently fuel cycle services were to play a key part in British non-proliferation policy, but at the outset the objectives were basically commercial.
Nuclear proliferation does not depend entirely on the diffusion of nuclear materials or facilities, but also on the communication of technical data and other pertinent information. Atoms for Peace led to a massive de-classification of hitherto sensitive material; for instance, over 11,000 technical papers on plutonium were de-classified.\(^{(84)}\) By December 1959 a total of more than 1300 overseas students had been trained at the UKAEA schools: the Reactor School at Harwell, the Calder Operations School, and the Isotope school at Wantage.\(^{(85)}\) Such a development was also a proliferation risk; for instance, an article in the March 1980 issue of The Bulletin Of Atomic Scientists noted that the presence of overseas students in US university nuclear physics departments was potentially a proliferation risk.

An indication of how such contacts can add to the proliferation risk can be seen from the following case. In 1949 the head of the Chemical Division at Harwell indirectly gave considerable assistance to French reprocessing research and development. During a visit to Paris Dr Robert Spence mentioned to Bertrand Goldschmidt that they had missed the best solvent during their wartime work in Montreal. The Americans had now found a far better solvent than the research team in Montreal. Spence, however, could not say what it was since the information was highly classified. Undeterred Goldschmidt asked two assistants to go through all the bibliographies on solvent extraction since the war. A reference was found which noted that tributylphosphate was successful in separating rare earth elements. As Goldschmidt notes this, "limited and unexpected help from the British enabled the French from the very beginning of their reprocessing work to make use of the best solvent."\(^{(86)}\) Thus increased contact between scientists either through personal contact or through co-operative research is a major contribution to
the spread of nuclear expertise.

The British had regarded international co-operation as highly desirable since the early 1950s. In 1953 the Waverley Report on the future organisation of the atomic energy project had noted the concern of the Commonwealth Relations Office. In particular the CRO was anxious that "the closest possible contacts at all levels should be developed between the corporation (the UKAEA) and the authorities concerned in Canada, Australia and South Africa". Moreover, the Waverley Report went on to conclude, "WE FULLY AGREE WITH THESE SUGGESTIONS AND RECOMMEND THAT A SUITABLE DIRECTIVE SHOULD BE GIVEN TO THE CORPORATION AT THE OUTSET."(87) (emphasis in original)

Consequently, the 1955 Nuclear Power Programme White Paper noted:

Her Majesty's Government have always been in favour of the greatest possible co-operation in the peaceful uses of nuclear energy, so that full use can be made of this great new scientific development for the benefit of the world.(88)

Both the government and the UKAEA had a clearly defined objective in relation to overseas collaboration. For the UKAEA collaboration with Commonwealth states was, according to the First Annual Report, related to the stage of development reached in each country. However, as the Report went on to conclude "in all cases the aim is the same: that the Authority and the Commonwealth country concerned should give each other all practical help to further their projects for their mutual benefit and for the benefit of the Commonwealth as a whole."(89) Already nuclear power was identified as fairly central to the future energy policies and economic health of a country. These benefits should therefore be exploited as soon as possible. This perception re-emerged in British non-proliferation policy during the NPT negotiations in the
1960s and during the 1970s.

Two Commonwealth states mentioned in the 1955 White Paper, India and South Africa, became advanced nuclear states in their own right. One of the UKAEA's first overseas contacts was with the Indian Department of Atomic Energy. In addition to the provision of technical advice the UKAEA offered to assist in the design and construction of a research reactor as well as provide the necessary fuel and other services. In 1957 the UKAEA provided fuel for the Indian swimming pool reactor; and moreover, had in the previous year enabled India to obtain the necessary materials for her research programme. During the currency of the 1962 - 63 financial year the UKAEA leased fuel elements for the second charge for the research reactor Apsara which was built to British design. None of India's research reactors are, or have been, subject to IAEA safeguards. Furthermore, India's plutonium reprocessing plant at Trombay which uses the Purex process, was built with equipment provided mainly by Britain and the United States even though the design was Indian. In the formative years of the Indian Atomic Energy Commission considerable technical assistance in the form of expertise and hardware was provided by the UKAEA. This assistance paved the way for greater Indian self-reliance.

The UKAEA's first principal contact with South Africa came in July 1957. An agreement for co-operation between the UKAEA and the South African Atomic Energy Board was concluded in that year. Indeed the UKAEA regarded this agreement particularly highly. Given South Africa's uranium reserves this was perhaps understandable. Closer collaboration as well as practical assistance came in subsequent years.

In addition to India and South Africa the UKAEA had contact with over forty overseas states. Moreover, the UKAEA took seriously its obligations incurred by British
membership of the IAEA. The IAEA was at this time largely concerned with the promotion of civil nuclear technology, rather than implementing and overseeing safeguard agreements. On 1 February, 1958 the European Nuclear Energy Agency (ENEA) was established. ENEA was the nuclear branch of the OEEC. ENEA's principal function was largely promotional and collaboration; for example, the Dragon Project agreement was signed in March 1959. This was a joint research programme on a High Temperature Reactor (HTR). The reactor was built at the Atomic Energy Establishment, Winfrith. However, as Shaw notes in his history of the Dragon Project, the UK was anxious not to appear as a source of proliferation of US information into Europe. Since a major objective of the government policy had been to re-establish full military partnership with the US, the British were careful to ensure that nothing prejudiced such collaboration. However, for Sir John Cockcroft, who had a strong personal commitment to European co-operation and Sir Edwin Plowden who shared the same view, Dragon was central to the UKAEA's R & D on high temperature gas cooled reactors. As it transpired each participating organisation in Dragon was able, eventually, to gain access to all the information available that was relevant to its activities, and which the project could legally divulge.

Dragon was not the only reactor project in which the UKAEA were heavily involved. In Norway the Halden Reactor programme involved scientists and technicians from Norway, Austria, Denmark, Sweden and Switzerland. In short, Britain sought to use these multinational agencies to promote the use of nuclear technology in Europe and elsewhere. It was hoped that such ventures would create a demand for power reactors which British nuclear industry could satisfy. Indeed the UKAEA provided "experts to the ENEA to advise on such matters as the liberalisation of trade in nuclear energy materials and equipment."
In contrast to the tight control of nuclear information between 1946 and 1953 Atoms for Peace resulted in a deluge of information. Many Harwell scientists welcomed such a development and they were keen for the widest possible exchange of information and contact with overseas colleagues. There were three conflicting issues here: scientific freedom; the need for military secrecy; and the growing need for commercial secrecy. The First and Second UN Conferences on the Peaceful Uses at Atomic Energy were held in 1955 and 1958. At both these conferences the UKAEA made major contributions. Indeed such was British prestige, especially in 1958 following the opening of Calder Hall, considerable interest was engendered in nuclear technology. Although gaseous diffusion technology was closely guarded, reprocessing and plutonium handling information was released in large quantities. At the 1955 Conference, for example British delegates presented papers on chemical principles in the separation of fission products from uranium and plutonium by solvent extraction and chemical processing of fission products. Sir John Cockcroft in a paper entitled Co-Operation By The UK In The Use Of Atomic Energy For Peaceful Purposes clearly outlined the British commitment to Atoms for Peace principles. On collaboration with both Commonwealth and other states Cockcroft stated that:

The UK is usually called upon in the first instance to contribute design information and other assistance needed for the building of a research reactor of really high intensity and to provide fuel elements for it.

Donald Pierson, the UKAEA's longest serving Secretary to the Board, noted that the First Geneva Conference effectively lowered the military security barriers which had severely limited post war exchanges on nuclear energy. Moreover, between the First Geneva Conference and the Fourth in 1970 the UK was party to 65 bilateral or
multilateral collaborative and co-operative international agreements.\(^{(104)}\) The scientific and commercial value of these ventures were the principal reasons for their conclusion in the 1950s and 1960s. Subsequently non-proliferation considerations were also taken into account, but such ventures were by no means occasioned by them. As Hill notes, "As the industry developed so the nature of the collaboration changed to reflect not only the group's commercial interests but also the high development costs, technical complexity and great size and cost of nuclear installations."\(^{(105)}\) This will be discussed in subsequent chapters.

Despite the wider availability of nuclear information, and it should be noted that British civil nuclear achievements by 1958 were influential overseas, many of the co-operative agreements concluded were, according to Pierson, in part directed to ensuring safeguards against the non-peaceful use of nuclear material, equipment or information.\(^{(106)}\) However, dissemination of nuclear information was not to be prevented on grounds of possible military use. Instead it was considered advisable to make the benefits available, albeit under controlled conditions. In the long term this policy was self-defeating. The training of scientists, mathematicians, metallurgists, chemists, physicists and engineers is, as some in the nuclear industry maintain today, a major proliferation risk. This contributed to the development of nuclear technology in several states; indeed, the training of personnel enabled states, India for example, to become self-reliant in the nuclear sphere. However, British nuclear scientists recognised that a complete embargo on information would not prevent others from discerning the laws of physics. The MacMahon Act demonstrated this basic fact. In the field of international relations the UKAEA had three objectives:

Firstly, exchanges of scientific information and personnel in unclassified fields with other states
and international organisations; secondly, special exchanges in certain limited areas particularly where classified or commercially valuable information is involved and lastly, but most importantly, supporting the promotion of British nuclear exports by providing for example, consultancy services and by the attendance of Authority staff at international conferences and trade meetings.(107)

9. CONCLUSION

By 1965 the tenor of British nuclear export policy was established. The active promotion of British reactors and fuels was a central objective of the domestic civil programme. Although sales of power reactors were disappointing, there were already signs that for Britain the real future lay in the provision of fuel cycle services for the world's nuclear industries. Moreover, the future market lay within the OECD, the developing world would remain incidental. In short, the export objectives were defined right at the beginning of civil nuclear power in the UK. The basic motives were commercial, but security requirements were not completely ignored. However, the failure to break into the world reactor market cannot be attributed to Government concern with proliferation. Subsequently export policy became closely related with non-proliferation objectives. Indeed in the British view there was no clash of interests between commercial imperatives and security considerations. This was to become apparent in the 1970s; however, the years 1965-1971 witnessed the gradual emergence of this position. The signature of the NPT and establishment of URENCO were the key events. It is to the 1965 - 1971 period that we now turn.
CHAPTER 5

BRITISH NUCLEAR EXPORTS 1965-1971

1. REACTOR POLICY

The decision to opt for Atomic Power Constructions’ AGR design for Dungeness B was to have a major impact on not only internal British nuclear policy, but also on reactor export prospects. The AGR originated in the late 1950s. Indeed a degree of technological determinism was involved in the 1965 decision. Preliminary study of an AGR design concept within the UKAEA began in 1957. Financial approval was obtained from the Government in January 1958, and construction started on a prototype at Windscale in November.\(^1\) The WAGR provided data for the second generation civil nuclear power stations.\(^2\) There were two design objectives. First, ensure a significant reduction in the cost of electricity generation by lowering capital costs, all important where exports are concerned; and second, increase thermal efficiency.\(^3\) Increased efficiency is a consequence of higher operating temperatures facilitated by use of enriched fuel and stainless steel fuel cladding. Basically the AGR owed much of its technology to the Calder Hall design.\(^4\) However, the very success of solving the AGR’s technical problems led the UKAEA increasingly to regard the AGR as its principal function.\(^5\) Consequently, as Williams notes, the 1964 statement on the future of nuclear power was largely predetermined by the UKAEA’s decision to build the WAGR in 1957.\(^6\)

The delays in announcing the reactor for the Second Nuclear Power Programme in 1965 combined with the impact of the 1964 White Paper had an immediate, though not necessarily apparent effect on the future export opportunities for British reactors. Indecision severely hampered efforts to sell British reactors overseas during a
crucial period in the mid 1960s when nuclear power was just beginning to expand.\(^{(7)}\)

Competitiveness with conventional power stations was the key to the success of a reactor design. Reliable operation for a utility was also important. Reduction in capital costs was crucial if the economics of electricity generation were to be acceptable to a utility. The cheapness of the APC tender was indicative of this necessity. Indeed the tenor of the CEGB and Government statements surrounding the Dungeness B AGR contract suggests that reactor exports were an important consideration in the decision.\(^{(8)}\) Following Dungeness both the UKAEA and remaining industrial consortia made efforts to sell the AGR overseas.\(^{(9)}\) Sir William Penney, UKAEA Chairman, observed that:

> The success of the AGR in the United Kingdom makes us confident that other countries overseas with similar requirements for nuclear power will also recognise the merits and economic advantages of the AGR. The opportunities are now arising for exploiting nuclear power overseas on a widening scale and making a great contribution to this country's need for exports.\(^{(10)}\)

Despite Dungeness, overseas utilities regarded the decision in favour of the AGR as an example of "nuclear nationalism". In their view there was no fair evaluation of the BWR and PWR designs which were also tendered. Whilst the British remained with indigenous gas cooled technology, the LWR was already capturing the international market. In 1965 two thirds of reactor orders in terms of capacity and fifty percent in terms of value went to American firms General Electric and Westinghouse.\(^{(11)}\)

In June 1966 the UKAEA, the Nuclear Power Group and Atomic
Power Group established the British Nuclear Export Executive (BNX) to promote British reactors overseas.\(^{(12)}\) The BNX had three main functions; first, it aimed to coordinate sales presentation and promotion of British reactor systems in overseas markets; second, it was to act as a focal point to which foreign utilities and other organisations interested in nuclear power could direct their enquiries; and finally it was to select, subject to any particular wishes of the customer, the consortium most suitable to handle each particular project.\(^{(13)}\) Despite BNX's activities no AGRs were exported between 1965 and 1971. There were several reasons for this failure. Arguably the most important was that there were no AGRs in existence with a proven record of high availability and generation of economic nuclear power. The US stranglehold of the European market ensured that whatever the technical and economic merits of the AGR, the LWR was more likely to succeed in any competition. In addition the USAEC was able to provide cheap supplies of LEU for the LWRs. Moreover, the sales effort of GEC and Westinghouse exceeded the modest efforts of British representatives.\(^{(14)}\) Finally, given the nature of base load electricity generation no overseas utility would build only one AGR, instead a series of reactors would have to be constructed.

Whilst a 650MWe AGR was considered economic to build and operate in British conditions, this was not the case in Europe. Consequently, European utilities found the AGR unattractive. The UKAEA realised this and made several design changes to the 600MWe design during 1966-67 in order to meet export requirements. The UKAEA, CEGB and the consortia managed to identify possible economies which would enhance the AGR's competitiveness.\(^{(15)}\) According to the Commons Select Committee on Science and Technology a reactor size of between 300 and 500 MWe was more appropriate to European requirements.\(^{(16)}\) The nuclear industry was keen to have a reactor tailored to sell
overseas. However, competition from the LWRs gave the "Rolls Royce" of reactors little opportunity. Some individuals in the nuclear industry had suspected that this would materialise back in October, 1965.

It would not be correct to assume that the failure of the AGR was entirely attributable to "market forces". LWRs made their breakthrough in Europe in 1958 with the Gargliano BWR. This decision did much to "overcome the impression that gas-graphite systems were more advanced." The ability of the US to guarantee cheap LEU fuel supplies combined with heavy subsidisation ensured US hegemony.

Although the LWR was predominant in 1966, the British were determined to carve out a share of the market with indigenous reactors. The rationales for exports were unchanged: economies of scale, benefits for the engineering industry, the domestic nuclear power programme, and the balance of payments. By the mid 1960s the balance of payments argument assumed a new urgency as trade deficits were one of the problems besetting the 1964-1970 Labour Governments.

AGR's were not the only British reactors available for export. The UKAEA's Reactor Group had designed and built a Steam Generating Heavy Water Reactor (SGHWR) at Winfrith Heath, Dorset. Most of the Authority's thermal reactor resources, however, were channelled into the AGR programme, which put the SGHWR at a disadvantage. In its favour was its size. If the AGR was considered uneconomic below 600 MWe the SGHWR at power ratings between 150 and 300 MWe was potentially ideal for export. Between 1965 and 1967 the UKAEA offered SGHWRs to Finland, Greece, Switzerland, and explored the possibility of exporting them to Czechoslovakia and Romania. J.C.C. Stewart, UKAEA Board Member for Reactors, wrote that:

in recognition of the importance attached to exports
the AEA has, with the agreement of British industry, started a campaign of tendering the SGHWR.\(^{(21)}\)

In November 1965 the UKAEA submitted a tender to two Finnish utilities for a 300 MWe SGHWR. This was the first time that the Authority had tendered directly because it possessed most of the design data. The consortia were reluctant to become involved for this reason.\(^{(22)}\) Peter Mummery, Deputy Director of the Atomic Energy Establishment at Winfrith, noted that the Finnish tender, "recognises the importance of the export market and that at this stage of the development of the SGHWR the Authority must take the lead in its partnership with industry."\(^{(23)}\) Furthermore, the UKAEA offered to include a complete fuel service to any reactor acquired.\(^{(24)}\)

Provision of fuel services is essential if reactor exports are to be successful. Guaranteed fuel services make reactor sales more likely since a customer is more likely to favour a company in a position to offer complete fuel cycle services. There are two advantages for the supplier. First, the export of reactors makes the customer dependent on outside technology, initially at least. Second once a reactor was sold there was a distinct possibility that substantial future business would follow; for example, the Magnox reactor supplied to Japan by GEC still has its fuel supplied and reprocessed by BNFL.\(^{(25)}\)

Other attempted reactor sales between 1965 and 1967 included the Nuclear Power Group and United Power company proposals to construct a 300 - 500 MWe station in Romania.\(^{(26)}\) A bid to sell a 120 MWe SGHWR to Switzerland failed as did an offer of a 300 MWe reactor to Greece.\(^{(27)}\) The BNX co-ordinated attempt to supply the Argentina CNEA with a 35MWe reactor collapsed.\(^{(28)}\)

The consortia's failure to export reactors did not go unnoticed, it was a major point of interest for the 1967
Commons Select Committee on Science and Technology.\(^{(29)}\) It concluded that:

The main and successful purpose of the British nuclear energy programme is to provide a new low cost source of primary energy for the home economy, it is necessary to examine critically... the past and present record of nuclear exports. The expected returns on the export of nuclear power stations were often given in the 1950s as an additional justification for the large investment of public money for nuclear R & D.\(^{(30)}\)

Committee members continued to believe that nuclear exports were desirable and the existing record should be improved. Its recommendations for the re-organisation of the British nuclear industry were not made solely with the domestic programme in mind. Exports appear to have been equally important. This can be established from the tone of the Committee's recommendations; for example, the establishment of a single boiler company would "assist the country in a determined and realistic effort to secure an improvement in foreign currency exports."\(^{(31)}\) Furthermore, it was concluded that the BNX should be disbanded even though it had been involved with eight export projects.\(^{(32)}\) Failure was attributed to a lack of co-ordination and the spread of resources over too many projects. A disjointed approach to the market confounded the problem.\(^{(33)}\) Instead, "an intensive survey of potential overseas nuclear needs and opportunities should be put in hand at once by the Board of Trade in close consultation with the engineering manufacturers and the UKAEA.\(^{(34)}\) One thing was clear: the Government, the UKAEA and the consortia were committed to the export of nuclear technology. Between 1965 and 1968 the British, Americans and Russians had by and large drafted the NPT. For the British there was no contradiction in a renewed export drive and creation of a treaty designed to prevent further weapons proliferation despite the civil-military
Although the Minister of Power, Fred Lee, had declared in 1965 that in opting for the AGR, "we have hit the jackpot with this,"(36) the AGR decision came to be regarded by some as "one of the greatest technological catastrophes of the nuclear age."(37)

Persisting with gas-cooled reactors effectively excluded Britain from the international market. Interminable delays and engineering problems experienced in translating a successful 35 MW reactor up to 660 MWe ensured the AGR's failure in the international market. Construction work on Dungeness B started in 1966, but the station did not reach full power until 1982. It should be noted that this was attributable not so much to the shortcomings of nuclear technology, but to the organizational weaknesses of the industrial infrastructure. The Dungeness contract was awarded to the weakest of the three consortia. Similar delays were experienced with other AGRs ordered by the CEGB and SSEB; for example, Hinkley Point B and Hunterston B were ordered in 1967, but did not achieve criticality until 1976.(38) This compares unfavourably with the Magnox stations which took, on average about four and a half years from start of construction to criticality. Failure of the AGR was one of the principal reasons for the further re-organisation of the nuclear industry. There was also insufficient work to justify three consortia. The consortia were reduced from three to two: The Nuclear Power Group (TNGP) and British Nuclear Design and Construction (BNDC). Lord Hinton went one step further. In his view, "if Britain is to regain her old prestige in nuclear power something more than re-organisation of the industry is necessary; it must be possible to offer reactors which are demonstrably better and more economical than those offered by the Americans."(39) However, this was not possible since the AGR was in effect all British industry could offer.
Tony Benn, Minister of Technology, outlined the objectives of the re-organised industry in October, 1968:

The two new design and construction organizations, which will be primarily responsible for the exploitation of British reactor systems at home and abroad, should be well able to stand up to international competition and should be capable of a powerful effort in overseas markets. (40)

Although a single consortium was recommended, Benn claimed that the Industrial Re-organisation Corporation's soundings had shown that a single design body would not be practicable. Two were necessary to preserve the existing links between private companies in Britain and abroad, links which would be necessary to sell British reactors overseas. (41)

Both TNPG and BNDC retained the desire to export reactors, for them exports were especially valuable given the likelihood of few domestic orders. S.A. Ghalib for instance, of TNPG wrote that:

Determined efforts are being made by the design and construction companies to sell AGRs in three highly developed countries with very large potential markets for nuclear power: FRG, Italy, Japan... More important, success in these countries will ease the way to getting the AGR accepted in other countries, and will pave the way for the earlier introduction of new reactor systems in these countries. (42)

It is important to note here that both the FRG and Japan had not signed the NPT. There was, in both countries, considerable hostility towards the treaty least it restrain their industrial development, and compromise export prospects. The British hoped that the NPT would make
nuclear trade easier, not more difficult.

In the Spring of 1970 TNPG and the Fuji Electric Company concluded a seven year technical agreement for the production and sale of AGRs in Japan. Under the provisions of this agreement Fuji were to be supplied with design information as well as training courses for its engineers. Moreover, later the same year McAlpine and a Tokyo based construction company reached agreement whereby the Japanese firm was guaranteed exclusive rights for the use of certain methods and techniques included in AGR civil engineering. Whilst this assistance to Japan was small compared to the numbers of LWRs being sold worldwide, it did nevertheless contribute to Japanese nuclear expertise. The Japanese hoped to by-pass first generation reactors by using British and American experience to proceed directly to more advanced systems, thus catching up ten years on the rest of the world. To this end a number of collaborative agreements were concluded to "buy in" technology. The consequences of these actions will not become apparent until the late 1980s. By then, in the view of Lonnroth and Walker, Japan will almost certainly count among the leaders in nuclear production and technology.

Between July 1969 and March 1970 TNPG and BNDC continued with the AGR sales campaign. Atomkraftwerks Planungsgellschaft invited tenders for a nuclear power station in the summer of 1969. BNDC submitted a tender for Austria's first nuclear power station, but withdrew in February 1970 when it learned that its bid came at the wrong end of a wide spectrum of prices. Other AGR tenders were made by TNPG to Italy and South Korea. BNDC were invited to tender for a nuclear steam supply system for a reactor in Spain. It should be noted that Spain refused to sign the NPT which was opened for signature in July 1968.

The SGHWR sales effort continued. SGHWR supporters
considered that its future lay in the export market.\(^{(50)}\)

It was hoped that the SGHWR would meet the needs of LDCs and other states more exactly than the AGR.\(^{(51)}\) In its Fifteenth Annual Report the UKAEA declared that it had made further efforts to exploit the SGHWR system in several countries.\(^{(52)}\) Furthermore, in 1971 the Authority noted that:

After the adoption in 1965 of a further gas cooled system, the AGR, as the initial basis to the second UK nuclear power programme, emphasis was placed more on the export prospects of the SGHWR system and its possible use in the UK as an eventual successor to the AGR... Although (the AEA) devoted substantial efforts to the promotion of the SGHWR system abroad, and is being offered as a suitable system in response to inquiries in a number of overseas countries, no overseas sales have yet been achieved.\(^{(53)}\)

The UKAEA, through the BNX, continued with its efforts to sell SGHWRs to Finland and Greece. The Finnish bid is indicative of the importance attached to reactor exports. Edmund Dell, Minister of State at the Board of Trade stated that:

Every suitable opportunity has been taken to make the Finnish authorities aware of the importance we attach to this contract, of the pre-eminent position of the UK in the field of nuclear energy, and our expectation that the award of the contract would be decided on commercial grounds as required by the EFTA convention.\(^{(54)}\)

Moreover, it was stressed that if the contract went to the Soviet Union for other than technical or economic reasons such a decision would represent a set-back to Anglo-Finnish relations. The Finns, however, announced in July 1968 that
no order for a nuclear power station would be made at that time. This was a disappointment for the UKAEA as it thought it had every reason to believe that all aspects of the Finnish specification could be met. Furthermore, disappointment was particularly acute because it was felt that the first successful overseas contract for a SGHWR would facilitate its success in the international market.

Despite a three year lobbying effort the UKAEA failed to build Finland's first nuclear power station, which was in the end built by the Soviet Union. Given Finland's "special relationship" with its eastern neighbour this is not surprising. It is significant that during the NPT negotiations the British nuclear export drive continued. This seems to suggest that the NPT was designed, in part, to provide an international framework for British nuclear exports.

UKAEA personnel were involved in negotiations with the Public Power Corporation in Greece for the supply of a 450 MWe SGHWR. It was expected that about seventy percent of the cost of the Greek power station would go towards paying for pre-fabricated components. Total cost was estimated at a figure in excess of £30m. Supply and reprocessing of fuel and training of personnel were also included. In return Britain was supposed to import a substantial quantity of Greek tobacco. Unfortunately for the UKAEA Greece announced in March 1970 that there would be no reactor. It is important to bear in mind that at this time Greece was governed by a military regime, and high ranking military officers were involved in the negotiations. This seems to suggest that Britain was prepared to provide reactors to governments with less than impressive human rights records.

Although Britain exported no power reactors, research reactors proved more successful. This may be attributed to
two factors. First, large power stations, unproven in reliable commercial operations such as the AGR and SGHWR are unattractive to electricity utilities. Second, they are expensive and out of reach of poorer states without large electricity grids. Research reactors, however, are more attractive because they are cheaper and the customer is usually a research institute. Furthermore, a research reactor allows a LDC to maintain its own prestigious R & D programme. This was certainly the case in the 1950s. Research reactors are important from the proliferation point of view for three reasons. First, they may provide the operators with experience of reactor physics and operation which can provide useful information for a weapons programme. Second, such reactors can provide the fissile material for a nuclear explosive even though it may take several years to accumulate sufficient plutonium 239. The ten to fifteen kilogrammes of plutonium used by India for a nuclear explosion in May 1977 was produced in the Canadian supplied CIRUS reactor. Finally, research reactors contribute to a state's expertise. They enable the owners to develop indigenous technologies which contribute to their eventual nuclear independence.

Fairy Engineering Ltd was contracted to supply nine research reactors to four different states between January 1968 and August 1969. The UKAEA announced that a reactor for Switzerland was formally handed over during the currency of its Fourteenth Annual Report. In the same report the Authority announced its support for the negotiations then in progress for the sale of a sub-critical assembly (Helen type reactor) to the Institute of Physics at Bucharest.

In the summer of 1969 Nuclear Engineering International reported a Brazilian order for six research and training reactors. The contract, worth £1,500,000, was for five
Helen reactors for training and basic research work at Universities and a 5MW Herald system for more advanced work.\(^{(65)}\) This contract appears to have been cancelled since no reactors were delivered. However, the point to note here is that the NPT, which was opened for signature in 1968, was not regarded by the British as a barrier to nuclear trade. Brazil refused to sign the NPT and it is conceivable that this could have been a reason for the cancellation.

However, given subsequent decisions to supply non-NPT states with nuclear materials and equipment this is unlikely. At the very least INFCIRC/66 Rev. safeguards would have to be accepted (see Chapter 11). Lack of finance in Brazil is a much more plausible explanation. Refusal to meet legitimate requests would only encourage such states to become more hostile to the non-proliferation regime. For example, a Brazilian delegation visited Britain to study the SGHWR and AGR. The UK Minister of Technology remarked:

\[\text{I believe that collaboration in the nuclear field between the two countries would be mutually advantageous and that the visit has contributed to this end. I shall, of course, do everything I can to promote it.}\] \(^{(66)}\)

Brazil was not the only Latin American state to receive nuclear assistance; Chile also benefited. In 1968-9 the UKAEA congratulated Fairy Engineering for securing an order for a Herald swimming pool reactor.\(^{(67)}\) A zero-power reactor and a hot cell were also provided. The reactor was based on the Herald facility at AWRE Aldermaston which uses aluminium alloy fuel enriched to 80% U-235.\(^{(68)}\)

The delays facing the domestic programme and industrial reorganisation contributed to British failure to establish a successful nuclear reactor export industry. As one leading
official noted the "ridiculous industrial structure" was the principle reason for failure. Also each Magnox station was built to a different design. Undoubtedly the spread of resources and fragmentation of the electrical and engineering industries undermined the effectiveness of both the domestic and export prospects of nuclear power. However, the long-term proliferation implications associated with reactor exports do not appear to have been adequately thought through. But failure to export power reactors cannot be attributed to implementation of a rigorous non-proliferation policy. On the contrary, it was hoped that the NPT would provide a framework in which exports could flourish.

2. FUEL CYCLE SERVICES 1965-1971

Expansion of nuclear power within the OECD provided a new market for the Production Group. This was apparent to the UKAEA:

The original concept was that a successful nuclear station could be exported as a turnkey contract. There will still be opportunities to export in the form of a turnkey contract; but most countries embarking on nuclear power stations seem to take the opportunity of educating their own industry, wherever possible, and to minimise the expenditure of foreign exchange. Thus the nuclear export business is likely to be largely confined to licensing arrangements and contracts for specialised items, such as fuel, material or complete fuel services, electronics and control devices and some other items specific to a reactor type.

This was not lost on the Select Committee of Science and Technology. It noted that, "a considerable contribution to our foreign earnings could be made by nuclear fuel
contracts. In a whole station contract ... the supply of fuel might well be worth more than the actual contract of the station."(71) In 1964 accountancy changes in the UKAEA's financing gave greater commercial freedom when a trading fund was established. There was considerable pressure from within the Production Group for this alteration.(72) This marked a firm commitment to, "going all out for world business in this particular field."(73)

The Magnox reactors in Italy and Japan provided regular work for the Production Group. Natural Uranium fuel elements had to be manufactured and reprocessed. By the end of 1967 overseas orders totalling 32.6 million were secured. The corresponding figure for the end of 1968 was £10 million.(74) Most of the fuel exported went to Latina and Tokai Mura; for example, 68.5 tonnes of Magnox for delivery to Latina between March and December 1967. 73 tonnes were contracted for Tokai Mura to be delivered between June 1967 and February 1968.(75) Significantly these contracts were not only the first large scale shipment of fresh fuel, but also of irradiated fuel. In 1966 the Authority noted:

considerable progress has been made during the year in extending the fuel cycle services of the Authority to overseas customers by achieving the first large scale international movements of irradiated fuel on a regular basis.(76)

There can be no doubt that the acquisition of reprocessing business was one of the Production Group's principal objectives. Transport-ation of irradiated MTR fuel from Marseilles to Leith for reprocessing at Dounreay was an important event:

the unique experience gained by these movements and the equipping of the "Steam Fisher" for the carriage of irradiated fuel place the Authority in a
favourable position to extend reprocessing services to other customers in any part of the world.\(^{(77)}\)

Thus fuel exports, unlike reactors, were already showing signs of future expansion. As early as 1963 the Production Group estimated that there would be reprocessing business from Belgium, France, the FRG, Italy, Norway, Spain and Sweden, and that more than 1000 tonnes of irradiated oxide fuel would arise in Europe by 1975. Two years later the Authority embarked upon an extensive marketing campaign to capture overseas orders.\(^{(78)}\) It seems that with the end of production of fissile material for military purposes in 1964 there was a danger that the Production Group would collapse for want of business. Hence the attempt to secure civil business from overseas since the domestic programme alone was insufficient to use all the spare capacity.\(^{(79)}\)

Although the reprocessing of spent power reactor fuel is a major part of the fuel cycle, there are other areas which were to prove equally lucrative; for example, conversion, fabrication, enrichment and transportation. Such services were provided by the UKAEA to Belgium, Canada, Denmark, FRG, France, Italy, Japan, Spain and Sweden between 1965 and the end of 1967.\(^{(80)}\)

One or two specific examples are useful because they illustrate the nature of the emerging international trading system in nuclear materials. In January 1967 the UKAEA secured a contract from ASEA, Sweden for conversion of approximately 35 tonnes of UF\(_6\) to UO\(_2\) in powder form to use in Oskarsham reactor fuel elements.\(^{(81)}\) Not content with existing business, the UKAEA were always seeking contracts; for example, Dr N.J. Franklin promoted the case for Britain as an alternative source of enriched uranium fuel in an address to the Swiss Association for Nuclear Energy in October 1967. Franklin suggested that the US could not meet all demands for enriched fuel.\(^{(82)}\)
In October 1966 the UKAEA agreed to supply replacement fuel until 1970 for the South African Atomic Energy Commission's SAFARI-1 research reactor. High enriched uranium fuel elements were manufactured at Dounreay. SAFARI-1's primary function was engineering testing, isotope production, fuel elements development and basic research. The R & D work at SAFARI-1 made an important contribution to South African nuclear independence. This experience enabled the SAAEC to build a second reactor which is not subject to safeguards: a fact all the more significant since South Africa has refused to sign the NPT.

Although SAFARI-1 is subject to IAEA safeguards its operation would not have prevented the accumulation of useful information for weapons research. Experiments involving the generation and control of neutrons, and the properties of materials under neutron bombardment would be critically important to the development of a "clean" tactical nuclear weapon. Moreover, it was suspected the operation of SAFARI-1 provided essential training of South African scientists who later developed the unsafeguarded uranium enrichment process based on the helikon aerodynamic system.

One of the Commons Science and Technology Select Committee's recommendations called for the establishment of a separate fuel company. But much of the pressure for this came from the Production Group itself and it lobbied the Government to this end. The 1964-1970 Labour Governments promised that this would be one of its objectives, but the new company did not appear until 1971. Legislation was delayed by the 1970 General Election, but the 1970-74 Conservative Government did not amend the bill required to bring BNFL into existence. This was one of the few occasions when a bill launched by one party was carried on by another after an election. The hiving-off of the Production Group represented a further commercialisation of
the fuel cycle services, a process which had begun almost a decade before. From 1968 to 1971 the Production Group continued to expand its overseas activities and several key developments in connection with fuel cycle services occurred in this period. Perhaps the most important of these was the creation of the multinational Uranium Enrichment Company - URENCO.

The Production Group's ability to provide the full range of fuel cycle services and its long experience derived from the military programme placed it in an advantageous position to secure overseas business. The Group made several successful bids for overseas contracts, and in the mid to late 1960s it built up a useful export market in processing uranium and irradiated fuel in particular. Indeed the Authority was particularly anxious to gain oxide fuel business. Because most of the reactors in operation, under construction or planned were either BWRs or PWRs the Group had to gear its services to cater for oxide fuel. Consequently authorisation was given for the oxide fuel "head end" reprocessing plant at Windscale, and to seek overseas business for it. It started operations in 1969 and was closed in September 1973 after a major accident. Moreover, the Authority's reprocessing division divorced its overseas sales drive from the reactor division.

The UKAEA reported in 1971 that the export of fuel services rose by over 22% to £5.4 million. At the end of the financial year outstanding export contracts were valued at £21 million. Moreover, the Minister for Technology noted in early 1970 that the export potential of the fuel cycle market would be about £1,000m in 1980.

During 1970-71 a "significant breakthrough" was made into the highly competitive US market. Three contracts for the supply of uranium hexafluoride (UF$_6$) were concluded with American companies. Combustion Engineering were to supply
3 million pounds of uranium concentrates for conversion over three years; 800,000 lbs of U3O8 to UF₆ for Western Nuclear, and over 1.5 million pounds for the Vermont Yankee Nuclear Power Group. All the UF₆ would be returned to the US for enrichment and fabrication into fuel elements.

Similar contracts were reached with other OECD states. One hundred and seventy tonnes of Spanish ore was converted to UF₆ for subsequent transfer to the USAEC's enrichment plants. This was destined for use in the Jose Carbera and Santa Maria de Gerona LWRs. Sweden, Switzerland and the FRG also had conversion contracts with the Production Group.

Fuel services were provided for the Magnox reactors in Italy and Japan. A reprocessing contract concluded with Japan on 10 April 1968 was reported to be worth over £2m. From the 160 tons of irradiated fuel about 180 kgs of plutonium would be recovered. Natural uranium fuel elements discharged from Magnox reactors at 3000 MWD/te, a typical figure, contains plutonium of the following isotopic composition: 17% PU.240, 5% PU.241 and 78% PU.239. Although not ideal for military purposes such plutonium can be made to explode. Significant reprocessing contracts were signed with Sweden, Spain, Italy, Switzerland and Canada. The contract to reprocess oxide fuel from the Swiss Bezna2 2 350MWe Westinghouse PWR was regarded as a breakthrough. Two observations may be made here. First, the recovered plutonium remained the property of the customer; and second, the UKAEA was reprocessing fuel from LWRs even though the CEGB and SSEB operated Magnox reactors. The first AGR did not begin producing power until 1976. One of the reasons for this was that economies of scale would benefit both utilities by way of cheaper fuel services for their reactors.

Provision of fuel services for R & D projects continued although they were not as lucrative as business from power
reactors. Some of the contracts were for advanced reactor projects; for instance, in 1969 the UKAEA supplied 200 kgs of plutonium to the Belgian, Dutch and West German 300 MWe prototype LMBFR which was to be built at Weisweiler.\(^{(98)}\) Such contracts were often extensions of existing collaborative and co-operative agreements. This suggests a correlation between such general arrangements and subsequent commercial exchanges.\(^{(99)}\)

3. URENCO

Possibly the most significant development in terms of proliferation was the signing of the Almelo Treaty in March 1970. The treaty created a multinational consortium to supply enriched uranium for AGRs and LWRs. Formation of the Uranium Enrichment company (URENCO) signified a transition from purely collaborative R & D projects to ones with purely commercial objectives. The negotiations which led to URENCO were important for the UKAEA since they represented:

> An event of great potential significance for the development of UK collaboration with other countries on the peaceful uses of atomic energy. It was also a most important step towards European Technological collaboration in an entirely new area - the creation of an independent capacity in Europe to provide enriched uranium.\(^{(100)}\) (author's emphasis)

URENCO illustrates the convergence of British commercial interest with non-proliferation objectives. The gas centrifuge adopted by URENCO poses a greater proliferation risk than the gaseous diffusion process. In particular, the size of the plant and low power requirements are two advantages. Consequently a centrifuge plant would be easier to build, operate and conceal. There were, therefore, good non-proliferation reasons for a multinational approach to the development of centrifuge technology.
URENCO and the gas centrifuge process have their origins in the 1940s and 1950s. Not only does the URENCO project reveal a great deal about British attitudes to proliferation, but also how nuclear policy is made. Furthermore, it is also an early example of how new technologies require multinational participation for their commercial development since national development is not always possible on account of cost.

Gas centrifuges were first considered as a method of isotopic separation during the Manhattan Project. It was identified as early as 1941 as a possible method of uranium enrichment. However, because the manufacture of large scale centrifuges entailed considerable engineering problems, no large scale plant was ever authorised. A small pilot plant was built, but closed down and all work on the centrifuge discontinued. Instead the US eventually built three gaseous diffusion plants for military purposes. Once the military demand for HEU declined, the spare capacity was used to provide fuel for the Atoms for Peace programme and supply cheap LEU for US supplied LWRs.

British work on the centrifuge was done by Hans Kronberger at Harwell, but was terminated in 1951 shortly after a machine blew up. Such was the size of early centrifuges that the amount of energy stored in massive rotating machinery presented too many problems for a commercial plant. Work was not resumed until late 1958 at Capenhurst. But the really significant work on the centrifuge was done by German scientists, Steenbeck, Zippe and Scheffel in the Soviet Union between 1946 and 1954. When Scheffel and Zippe returned to the FRG in the late 1950s they continued their research and published their results. A renewed interest in the centrifuge was occasioned by the details of Zippe's research. Research in the Netherlands and US continued, and new programmes commenced the UK and FRG. Proliferation implications led
to the US in 1960 to request the three European states to classify their work. Nevertheless research continued independently until 1968. In the UK a complete centrifuge design emerged in 1965 - 66, and subsequently an experimental cascade and prototype plant were constructed at Capenhurst.\(^{(106)}\)

Work was also continued on gaseous diffusion technology. In 1967 the progress and potential of both processes were critically reviewed in the UK. A high level group was set up within the government to assess enrichment policy. Both Solly Zuckerman and Alan Cottrel came out in favour of the centrifuge \(^{(107)}\). Under European conditions, partly because of the high projected cost of power compared with that available to the USAEC, the centrifuge was considered more economic. A centrifuge plant consumes very little electrical power compared to a gaseous diffusion plant\(^{(108)}\). However, it was decided that gaseous diffusion should not be completely abandoned at this stage. Since centrifuge R & D was subject to continual review, retention of gaseous diffusion capability was a prudent hedge against failure. It seems that non-proliferation considerations were also involved. For example, if the British completely abandoned gaseous diffusion this would indicate to other states the advantage of the centrifuge.\(^{(109)}\) Indeed British centrifuge work was highly classified since its military implications were clearly recognised.\(^{(110)}\)

By 1968 the three European projects had reached a similar stage of development. Given the view that international collaboration was necessary to achieve a fully competitive enrichment plant in Europe, approaches were made at Government level aimed at achieving a joint venture.\(^{(111)}\) Multinational co-operation was the ideal solution to conflicting interests. The Dutch feared that co-operation with the FRG on their own would lead to their absorption by a larger German project. British participation would maintain a balance. For the British commercial interests
were as important as non-proliferation objectives. British participation would ensure that a proliferation sensitive technology was developed within one organisation rather than independently. Safeguards provisions would be easier to operate, and multinational operation would ensure that each participating state would monitor its partners. Concern with German work in particular cannot be excluded as one reason for British participation. URENCO would draw in all work under one organisation and maintain tight control of centrifuge technology. However, these considerations were not made public. Public announcements focussed on the commercial reasons. On balance it seems that commercial reasons were the principle but not only reason for URENCO's creation. The non-proliferation advantages of multinational projects, such as URENCO, were not highlighted until the 1970s. As a Dutch official on the URENCO's Joint Committee remarked, the concept of multinational fuel cycle centres had not come into prominence in the mid 1960s. Nevertheless, the reasons for opting for the MFCC concept, "were as valid then as they are now: to strengthen international co-operation in technology and research, and to reinforce non-proliferation assurances through international involvement in the utilization of advanced nuclear technology." Similar R & D occurred in the FRG and Netherlands largely because the US had discouraged establishment of a European enrichment plant. Both states were unwilling in the long run to remain totally dependent on the US for supplies of LEU. Whilst the Americans abandoned the centrifuge, the Europeans continued. This irritated leading US JCAE members. Despite first public indications in 1968 of a collaborative agreement for provision of commercial enrichment services it took several years of negotiation before the Almelo Treaty was signed. According to Harold Wilson the R & D work on the centrifuge and the possibilities of a collaborative agreement were brought to his attention by Frank Cousins in Spring 1966. It should
be noted that such a venture was under consideration in parallel with the NPT negotiations. Clearly commercial interests were not incompatible with non-proliferation objectives. In November 1968 the Minister for Technology announced that negotiations were to begin between the governments of the UK, FRG and Netherlands with a view to establishing joint enterprises for the construction and operation of centrifuge enrichment plants. Ministers met in The Hague on 25 November.\(^{(117)}\)

During the negotiations and exploratory exchanges the British were reluctant to disclose too much information. They feared that this might reveal valuable information without receiving anything worthwhile in return, or compromise sensitive proprietary data. To expedite negotiations a limited exchange of technical, costs and plant economics data took place in early 1969. Sufficient confidence was gained to enable the parties to proceed. Nevertheless there was a further year of detailed negotiations as the treaty was not signed until 4 March 1970.\(^{(118)}\)

The Tripartite Agreement created two organizations: URENCO and CENTEC. BNFL holds one third of the shares in the company. Both organisations are under the supervision of a Joint Committee of government officials. URENCO has commercial freedom and acts according to commercial standards of profitability.\(^{(119)}\) CENTEC had, when incorporated on 29 July 1971, three principal functions: first, it was to gather all information arising from centrifuge R & D programmes in the three member states FRG, UK and the Netherlands; second, co-ordination and control of further integrated R & D; and third, design and construct centrifuges and enrichment plants to order of its customers. In translating the Treaty into a working arrangement the signatories looked to exploit the technology at an industrial level rather than by government bodies.\(^{(120)}\) URENCO markets the LEU produced at Almelo
and Capenhurst. Despite these commercial overtones non-proliferation and security concerns were not ignored. The treaty included specific safeguards and security provisions; for example, Articles II, VI and VII required, amongst other things, that any information equipment, source or special fissionable material will not be used by, or to assist, encourage or induce any NNWS to manufacture or otherwise acquire nuclear weapons. Article VII, paragraph (b) notes that, "the procedures resulting from any additional obligations in relation to safeguards binding upon any of the contracting parties pursuant to an agreement of agreements concluded with the IAEA" shall be applied. This mixture of commercial and non-proliferation interests in the British position became more apparent in the late 1970s. For the British Prime Minister, of the other technological collaboration projects then in train, the European Launcher Development Organisation and the European Space Research Organisation, the European Air Bus and Multi role Combat Aircraft, the most important discussion centred on the Anglo-German-Dutch collaboration on the centrifuge.\(^{121}\)

There were several ready reasons for British participation. Existing policy sought to expand the overseas fuel cycle operation of the Production Group but crucially the unreasonable US requirement that any LEU supplied for AGRs should be safeguarded amplified the attractions of an independent, and cheaper, source of LEU. The Minister of Technology announced in December 1969 that:

> The balance of payments advantages will flow from the fact that the work will be undertaken here, and we believe that this will be competitive with the American price and therefore this will be a gain in our balance of payments, although I cannot give exact figures.\(^{122}\)

All the URENCO participants sought to end the US position
as monopoly supplier of LEU. A rapid growth in the demand for enriched oxide fuel made it, "essential to establish in Western Europe a substantial and growing capacity for uranium enrichment."(123) For the British the desire to exclude the US from the market was in line with fuel export policy in general.(124) The potential earnings from the enrichment market were expected to rise from $60m in 1970 to around $260m per year by 1980. In this respect a major advantage of the centrifuge was its economy in construction and operation. George Geoghegan, Chief Technical Director, Capenhurst, noted that:

Commericially, it is hoped that the bigger and more widely based organisation and a competitive price for separation work will secure a large share of the European market ... the centrifuge process offers the greatest potential for a local and visible source of enrichment for the European nuclear power industry.(125)

The URENCO decision was related to reactor export policy. As the AGR burned enriched oxide fuel, the greater the number of sources of supply, and the cheaper the fuel especially if the plant was under British control, the more likely that overseas customers would look favourably on the AGR.(126) Indeed an alternative source of LEU was considered essential if the British were to sell ARGs overseas.(127) This had been one of the reasons for the triumph of the LWR; namely, the ability to supply cheap and guaranteed LEU.

The US used its position to further its commercial and non-proliferation policies. Relationships of dependence enabled the US to monitor national programmes. Moreover, spent fuel of US origin could not be reprocessed without permission. Subsequent US actions in the 1970s, the Nixon Administration stopped providing enrichment services, justified the wisdom of the URENCO decision. Predictable
and assured supplies are essential. This objective could best be satisfied by the existence of several suppliers. Once again unilateral US actions encouraged trends which were potentially inimical to the bests interests of non-proliferation.

Since American reliability was considered suspect assured fuel supplies for national nuclear programmes was, and remains, a fundamental URENCO objective. Assurance of supplies was considered to have important non-proliferation advantages. (128) Subsequently URENCO was presented as a form of organisation which could meet participants commercial interests and enhance their energy security by providing assured fuel supplies without compromising non-proliferation objectives.

4. CO-OPERATION AND COLLABORATION 1965 - 1971

Exchange of information and international collaboration agreements on specific areas of nuclear research and commercial exploitation continued as an essential part of British nuclear policy. Formal and informal discussions at governmental and non-governmental level were regarded as a valuable mechanism for promoting British nuclear exports. Invitations were extended to representatives of overseas nuclear industries and utilities to visit UKAEA, CEGB and SSEB installations. UKAEA officials went on lecture tours to advertise British nuclear services. During a tour of Argentina and Brazil an Authority official took the opportunity to discuss with the respective national energy organisations ways in which the UKAEA could assist their plans for the introduction of nuclear power. (129) The British Nuclear Forum tried to establish through continental and other overseas nuclear fora a sound understanding of, and confidence in British nuclear technology. Considerable importance was attached to establishing confidence in the ability of British industry to design and supply a wide range of plant and equipment directly
associated with reactor technology. Indeed the BNF regarded export sales as a vital part of its affairs.\textsuperscript{(130)}

Collaboration and co-operative agreements concluded between the UKAEA and its counterparts in the OECD in the 1950s and early 1960s continued. These were basically R & D projects such as the Dragon HTR project at Winfrith. Between 1965 and 1971 there was a transformation from the general to the specific. R & D began to give way to more commercially based projects such as URENCO. Despite this trend, new general collaborative agreements were concluded and older ones renewed; for example, the agreement between the UKAEA and the SAAEC, due to have expired in July 1967, was renewed for a further five years.\textsuperscript{(131)}

Several collaborative agreements concluded were of a specifically commercial nature. In April 1967 the Nuclear Power Group and Belgian-nucleaire reached an agreement for joint promotional efforts for the AGR in Belgium. Furthermore, NPG hoped that links with Belgian industry would result in considerable economies for the AGR for the European market.\textsuperscript{(132)} For this reason the Select Committee thought that manufacturers would best be able to sell reactors, whether AGR, HTR, SGHWR of eventually FBR, in close collaboration with European companies and suppliers of heavy power plants.\textsuperscript{(133)}

In January 1965 a new company was created for the manufacture, supply and reprocessing of AGR fuel for the European community. Nukleardienst was set up jointly by the West German company NUKEM and the UKAEA.\textsuperscript{(134)} It seems clear that the British sought to use collaborative agreements to promote the AGR as a commercially viable proposition. At the same time the UKAEA concluded an agreement with Italy to provide fuel services.\textsuperscript{(135)} Under the terms of this agreement natural uranium and oxide fuels would be made at Talamona. A complete fuel cycle service would be provided, but the Windscale B204 plant would be
used until such times as a reprocessing plant was built in Italy. This was the second overseas reprocessing plant that the UKAEA was prepared to build. Similar assistance had been offered to Japan.

Two particular R & D arrangements prospered between 1965 - 1971. In 1966 - 67 the UKAEA assisted the Pakistani Atomic Energy Commission with its plans for the Institute of Nuclear Science and Technology at Islamabad. PINSTECH is PAEC's principal research centre and is to Pakistan what the Bhabha Atomic Research Centre is to India. It was intended to be Pakistan's leading research and training centre. Subsequent assistance included the UKAEA's help on a study of a 600 MW nuclear power station for a desalination plant. In 1968 Pakistani engineers joined AEE Winfrith to work on the SGHWR.

The UKAEA's relationship with the SAAEC continued to prosper. Many of South Africa's nuclear scientists and engineers were either of British origin or British trained. In 1969 - 70 for example, two scientists were attached to the SGHWR design team at Winfrith. A collaborative agreement between the two organisations was extended until 1977. Moreover, specific information on the SGHWR was supplied to the South Africans who were exploring options for a commercial nuclear power station. These exchanges with Pakistan and South Africa continued even though it was clear that neither state would sign the NPT. Collaboration at this level is not at variance with Article 1 of the NPT; nonetheless, provision of such information on reactor designs and operations contributed to the eventual independence of its recipients. Therefore, by the time future contacts with both states were foreclosed in the late 1970s the damage had already been done.

In the autumn of 1971 BNFL, CEA (France) and KWG (FRG) formed United Reprocessors. Its main purpose was to market and promote services for the reprocessing of
irradiated fuel from nuclear power stations burning oxide fuel. The first public announcement of the multinational discussions was made on 22 May 1970, but United Reprocessors was not incorporated in the FRG until 1971. BNFL, as with URENCO, held one third of the shares. Similarity between the two does not end here. Like URENCO UR GmbH was established to provide a greater assurance of supply and secure non-proliferation objectives. It would also prevent needless competition and prevent financial disaster for individual participants. The Production Group was the driving force behind UR GmbH. But first URG had to convince the EEC Commission that it was not a cartel. In its defence URG stated that it fully intended to charge the same price for reprocessing services to all customers in the EEC in accordance with Community law.\(^{(144)}\) This development has to be put in context of UKAEA's increasing efforts to acquire additional reprocessing business.

URENCO and United Reprocessors provided indirect assistance to the West German nuclear programme. During the 1960's the FRG sought to shift German industrial structure towards high technology with particular emphasis on nuclear power which was to become central to German energy security. This objective, however, was "potentially impeded by the lack of assured uranium supplies, enrichment and reprocessing capacities.\(^{(145)}\) Therefore the efforts to overcome these difficulties led to German participation in URENCO and UR GmbH. British encouragement contributed to a much greater level of German nuclear independence. However, multinational organisations provided a useful mechanism to maintain security interests since it involved close supervision of the NNWs' activities.

Stable nuclear relationships appear to have been an important element in British policy. This explains, in part, why contact with non NPT states continued. Japan for example harbourd doubts about the treaty's impact on its nuclear industry in particular. Indeed the Japanese did
not ratify the Treaty until 1976. This explains in part the 1968 UK - Japanese collaborative agreement since it provided, amongst other things, British assurance of the continued supply of fuel needed by Japan's Magnox reactor.\(^{(146)}\)

British companies found a lucrative market for non-specific nuclear technologies and hardware which had a nuclear use. Although the Swedish 760 MWe BWR at Ringhals was built by ASEA-Johnson, its turbines were provided by English Electric.\(^{(147)}\) Sweden provided several such contracts for British companies.\(^{(148)}\) In the summer of 1969 Westinghouse (US) won a contract to supply South Korea with a PWR; however, English Electric supplied part of the reactor plant, most of the conventional plant, and was in charge of plant erection. In addition George Wimpey and Company were responsible for the heavy construction work.\(^{(149)}\) Conventional plant includes electronic control systems which are, in the main, indistinguishable from those used in conventional power stations. As events in the late 1970s were to demonstrate, 'grey area' technologies do pose a major proliferation risk.\(^{(150)}\)

5. CONCLUSION

Although the BNX was folded up at the beginning of 1969 this did not indicate any lack of interest in nuclear exports.\(^{(151)}\) By 1971 BNFL was set to expand on the sound basis established by the Production Group. Here the industrial organisation was ideally suited to compete on the international market unlike the consortia system. The further rationalisation of the industrial structure, however, did not lead to any new orders for Magnox, AGR or SGHWRs despite an intensive effort. Dissatisfaction with the export record had been one of the Select Committee's principal subjects of interest.\(^{(152)}\) Moreover, the Committee originally thought that one 'boiler' company would be more effective\(^{(153)}\), but it was not until the
1970s that the NNC was left as the one 'boiler' consortium. It was already clear that future British export successes would lie in the fuel cycle business rather than reactors. Indeed BNFL's fuel business and its organisation was to play a central role in British non-proliferation policy in the late 1970s.

British commitment to nuclear exports remained undiminished between 1965 and 1971. In particular, the fuel cycle services offered by the Production Group were intensified, and a firm foundation was laid for its successor, BNFL, in the 1970s. The increased commercialisation, however, was not a departure from existing policy. As noted in Chapter 4 the birth of this policy was more or less parallel with the emergence of civil nuclear power in Britain. Security and proliferation objectives were not ignored, but it seems that it was not until the late 1960s, and well into the next period, before these issues were given a much higher profile.
CHAPTER 6

BRITISH NUCLEAR EXPORTS 1971 - 82

1. INTRODUCTION

By 1971 further reactor exports failed to materialise, but not because the British government vetoed sales for fear of contributing to the spread of nuclear weapons. Fuel services, however, were set to expand dramatically in tandem with the increase in nuclear power. However, increasingly in the 1970s British commercial interests were also considered to be in the best interests of non-proliferation. But as noted in Chapter 4 pursuit of reactor and fuel exports had figured significantly in the deliberations prior to the launch of the first nuclear power programme. In short, British commercial objectives remained unchanged.

2. REACTOR POLICY

In contrast to American, French and West German LWRs, British gas-cooled reactors failed to break into the international market. Indeed between 1967 and 1974 no new power reactors were ordered in Britain. There was no new reactor construction until 1980 when work started on two AGRs each for the CEGB and SSEB at Heysham and Torness. Dearth of orders led to the further re-organisation of the nuclear industry. The remaining two consortia were reduced to one when the National Nuclear Corporation (NNC) was established in 1973. Given this shortage of domestic orders one would expect pursuit of exports to assume a new urgency. Promotion of British reactors continued, but with no success as the LWR reigned supreme. However, the continued indecision that dogged reactor choice for the domestic programme compounded the problem; for instance,

Historically one major reason that there have not
been more system exports of British reactors would seen to be indecisiveness of the policy at home. We have seen over the last 15 years too much dispute among the authorities, the industry and the commentators about what Britain ought to be doing, and there has been no sound home market against which to convince potential purchasers of nuclear power that they buy a British system.(1)

Internal wrangling over reactor choice, SGHWR or AGR or HTR or PWR, ensured that the NNC would not export a reactor of any kind. Towards the end of the 1970s, however, the export drive was renewed. This time LDCs and NIDCs were the target; for example, Israel and Kuwait.(2) Other possible Magnox sales involved Chile, Turkey and Algeria.(3)

Failure to export reactors does not mean that this was a consequence of non-proliferation policy. The spirit was willing but the flesh was weak. Several explanations may be advanced for this: organisational, lack of commercial freedom, all the Magnox stations were of different design, residual military influences, guaranteed cheap supplies of enriched uranium from the US, and domestic engineering problems, Dungeness B AGR in particular(4). There is an element of truth in all of the observations, but they should not obscure the importance attached to nuclear exports. After all the British had enthusiast-ically embraced the Atoms for Peace concept. That this corresponded with commercial interests was no coincidence. British reactor export drives were, therefore, not the product of some conspiracy concealed from public view; on the contrary, they were a publicly stated policy objective. Thus the failure of British reactors in the export market cannot be regarded as a non-proliferation policy through denial.

The first years of the 1970s witnessed further
rationalisation of the British nuclear industry in addition to continuing technological teething problems with the AGRs. In 1971 the last Magnox station at Wylfa, and the largest at 3200 MWe, went critical. The first AGR did not achieve full power until 1976. In Spring 1973 the various sections of the reactor design and construction industry were amalgamated into the National Nuclear Corporation with GEC as the major shareholder.\(^{5}\)

GEC, however, favoured the US LWR and not the British AGR. Indeed GEC were responsible for Britain's only major commercial nuclear equipment export in the early 1970s.\(^{6}\) GEC's Reactor Equipment Division in conjunction with Westinghouse supplied £60 million worth of equipment for a PWR under construction in South Korea. GEC were responsible for supply and installation of turbine generation plant and extensive mechanical and electrical equipment.\(^{7}\) This typified the trend in British reactor exports in the 1970s. Whereas no complete reactors were supplied a lucrative trade in reactor, particularly LWR, components developed. Reyrolle Parsons, for example, were contracted to supply nuclear safety monitoring and associated instrument cubicles worth £96,000 for Oskarsham II and Barseback I BWRs in Sweden.\(^{8}\) A British company won a contract to supply two 1020 MWe turbine generators for Taiwan's four nuclear power stations. This deal was reported to be worth £90 m; however, it was cancelled later the same year.\(^{9}\) Other contracts included supply of process control instrumentation for the Swedish Ringhals 3 and 4 nuclear power stations, and nuclear control rod drives for the FRG.\(^{10}\) Non-nuclear components were supplied to utilities and research organisations in Canada, Argentina, Belgium, Finland, France, India, Japan, South Korea and Switzerland.\(^{11}\) In short, although there were no reactor exports, some British companies did well in selling LWR components overseas.\(^{12}\)

Such exports illustrate the problem of control of
technologies and equipment which have no obvious nuclear use. P.C. Warner of Northern Engineering Industries Ltd. noted that:

You could not tell by looking at switchgear transformers, or electrical equipment generally what form of power station nuclear and fossil fuel burning they were associated with.\(^{13}\)

Furthermore, this was reflected in the organisation of the companies involved since manufacturers do not specialise exclusively in nuclear work:

In short there is no such thing as the nuclear manufacturing industry, in the sense of a sector that is hived off and separately recognizable.\(^{14}\)

There appears to be no publicly available evidence to suggest that the British thought seriously about the potential problems of non-specifically nuclear materials and equipment, the Export of Goods (Control) Orders, notwithstanding. Once the Pakistani enrichment project came to light in the late 1970s the issue was re-examined.\(^{15}\)

By the early 1970s the time had come to consider the reactor type to form the basis of the third nuclear power programme. As in 1965 there were strong pressures to favour indigenous technology, in this case the SGHWR. Unfortunately for its institutional backers, the UKAEA, the SGHWR had been unsuccessful abroad. Translation of art into article, a problem encountered by the AGR, was partly to blame. In particular, there were difficulties in producing a 660 MWe design; the UKAEA had only experience with the 100 MWe Winfrith SGHWR.\(^{16}\) This did not bode well for export success although the original attraction of the SGHWR in the mid 1960s was its suitability for states with small grids hence the preference for reactors in the 100 to 300 MWe range. Moreover, construction costs were against
further commercial development. The Economist noted that, "the SGHWR may be a splendid all-British design as its proponents claim it is but its export prospects are nil and spending more money on its development will be a waste". (17)

The Economist regarded preference for the SGHWR as little more than nuclear nationalism, and if in 1971 a LWR was adopted this, "would be tantamount to admitting a colossal failure of Britain's own nuclear power programme from the early 1950s onwards". (18) However, it ought to be noted that one of the principal rationales offered for British designed reactors was the export factor; furthermore, with balance of payments deficits the purchase of an American reactor was hardly the best policy. Since there was a deficit, which in one month reached £289m, the Government was not eager to spend more money abroad than it had to. (19)

Several committees were established between 1971 and 1977 to advise on reactor choice and organisation. Members came from the Government and nuclear industry. The most important committee led to the Vinter Report of 1971. Both the Nuclear Power Advisory Board and Central Policy Review Staff examined the issues, but came to indeterminate conclusions. For all these committees reactor exports were not far from mind; indeed, one of the principle considerations was to choose a reactor which would have a reasonable chance of breaking into the world market. At the time of the Vinter Report the British Nuclear Forum circulated a private report which estimated that the potential benefits of being able to sell the most popular nuclear reactors to the rest of the world could amount to £1500m over the next decade. (20)

The NPAB's remit was to advise the Government on the reactor system for the next stage of the nuclear power programme. However, it only narrowed the field to the
SGHWR and the PWR. But the NPAB recognised that the export of nuclear power stations would be very difficult whichever system was favoured. The NNC saw an opportunity for fuel and component sales if the PWR was adopted.\(^{(21)}\) Proven capability and safety are crucial since they are taken into account by overseas utilities. They are unlikely to opt for an unproven and unreliable system; the experience with the AGR and SGHWR served too readily as a reminder.\(^{(22)}\) For this reason the PWR, in GEC's view, would have been the sensible choice.

In the end the Government opted for the SGHWR; 4000 MW capacity was ordered in July 1974.\(^{(23)}\) Controversy did not end here however. Sections of the NNC, GEC in particular, did not rate the SGHWR's export prospects. One official noted that the SGHWR was, "not big enough to create a viable nuclear industry ... it's nonsense to think about exports".\(^{(24)}\) Donald Clark, resigned from the CEGB Board of Directors noting that British opposition to PWRs was largely chauvinistic.\(^{(25)}\) In fact although the nuclear construction industry was theoretically united in the one organisation, interest groups lined up behind specific reactors which they had been involved with prior to 1973. These factions tended to emphasise the export potential of their reactor system and denigrate the opposition. For example, the High Temperature Reactor (HTR) similar to the ENEA's Dragon Reactor was also under consideration. C.A. Rennie, former head of this project, argued in 1978 that a demonstration HTR in conjunction with one or two new AGR held out much better export prospects than a PWR.\(^{(26)}\) In 1978, however, the SGHWR order was cancelled; instead, both the CEGB and SSEB were permitted to order one dual AGR station each.\(^{(27)}\) This enabled the nuclear industry to remain intact, without the order it would have been difficult, if not impossible to re-enter the export market. The protracted decision-making process had a deleterious effect on export prospects. This was clear to some within the nuclear community. Referring to the CPRS report on the
future of the UK power plant manufacturing industry the Journal Of The British Nuclear Society noted in April 1972 that:

The UK industry is in a very difficult position, since it does not have a proven capability in any single exportable reactor and has no experience of either of the reactors which are being sold in overseas markets, the PWR or BWR. Without a firm commitment to a nuclear system the industry has no hope of developing an exportable product for five years and probably for ten. Indeed given the lead which the foreign competition already has, there is some risk that, subject to the outcome of the present nuclear review, the UK industry may never achieve a capability in an exportable nuclear product. (28)

This was an accurate estimation since US, French and West German LWRs were the preferred reactors worldwide. Of the two hundred plus reactors ordered between 1971 and 1982, only eleven were not LWRs. However, the economic crisis of the mid 1970s and the Three Mile Island accident combined to curtail the expanding reactor market so much so that for the first time reactor orders were cancelled. Consequently the chances of the NNC entering the market, even assuming a PWR was chosen, were slim.

In evidence to the House of Commons Select Committee on Science and Technology the CEGB outlined the criteria for reactor choice. The Committee's report refers to the Board's memo as a succinct statement on the issues at hand; it is, therefore, worth reproducing in full:

To be satisfactory to both purchaser and supplier a reactor system must be one that can be built to time, achieve a satisfactory performance and life (sic) at a competitive price and still yield a profit to the manufacturer. There is benefit in choosing a system
for which development and overhead costs per reactor can be shared by collaboration or which will command export sales to augment the limited volume of potential home sales, or better still, both. (29)

Again there is no mention of the proliferation risks attendant with reactor exports; furthermore, the tenor of the Committee's Report suggests that reactor export potential was one of the key factors influencing reactor choice: a point which was noted by the Secretary of State for Energy at the Sunningdale Seminar on reactor choice in May 1977. (30) Before the establishment of the NNC, the BNDC and TNPG clearly favoured specific systems. TNPG, probably the strongest of the two, was in favour of the SGHWR which was not unremarkable since it had built the Winfrith SGHWR. But TNPG's corporate view on reactor choice does illustrate the relationship between domestic policy and export success. In evidence to the Committee TNPG argued that "for the system to be capable of proper commercial exploitation, it would require three or four orders from the CEGB". Moreover, unless a start was made in the UK no European utility could be expected to order it. (31) In contrast both BNDC and the Department of Trade and Industry, whilst acknowledging the SGHWR's technical merits, were less optimistic about its export potential. Ned Franklin noted in 1975 that the UK had no right "to be giving our attention to overseas SGHWR sales in any big way until we are a lot further down the pipe in building them at home". (32) Both BNDC and DTI took the view that since the LWR was preferred worldwide the UK would be unwise to opt for the SGHWR. The North of Scotland Hydro Electricity Board's decision to abandon plans for a SGHWR at Stakeness, Banffshire probably killed the reactor's export chances. (33)

Although no power reactors were exported the UKAEA did manage to expand its reactor service operations. For example, the Authority's Reactor Plant Inspection Service
achieved its first overseas contract in 1971. A contract for carrying out inspections of two PWR vessels under construction in Belgium was worth about £190,000. (34)

In summer 1972 a second contract was won to carry out pre and in-service inspections on the pressure vessels at the Borssele power station in the Netherlands. (35) During the financial year 1972 - 1973 the Reactor Services Division, including the Dragon project earned, £4,649,000. (36)

Whilst such services to OECD states do not really contribute to the proliferation risks such services have to be put in the context of British foreign nuclear policy. For example, the UKAEA's objective behind provision of such services was clear enough:

The Authority have undertaken work for overseas customers on commercial terms. The receipts earned from this work offset some of the costs to the UK of the nuclear power development programme and this work establishes contact with overseas nuclear authorities which may later be of value to the UK nuclear industry. (37)

In the early 1980s a renewed attempt was made to sell gas-cooled reactors overseas, only this time LDCs were the object of attention. The NNC tried to sell a 300 MW Magnox reactor to Chile with BNFL offering relevant fuel cycle services. (38) However nothing came of this campaign. Although Chile has not signed the NPT this is unlikely to have been a decisive factor for two reasons. First, the NNC cannot proceed with any sales negotiations without government approval; nor would the corporation go to the expense of preparing a bid only to have the government veto any subsequent contract. (39) As the NNC noted at the Sizewell B public inquiry:

It is .... a matter for the UK government to determine whether NNC is free to attempt to sell a
nuclear power station to a particular country, and also what requirements should be set by the UK, the IAEA or both, for features facilitating the application of full scope safeguards ... NNC does not conclude overseas relationships without seeking endorsement of the UK government.\(^{40}\)

Second, Britain has had a longstanding nuclear relationship with Chile such as the collaborative agreements in nuclear research concluded in the 1960s, and the supply of a HERALD Research reactor and associated fuel services in 1969.\(^{41}\) Provision of finance within Chile and internal disputes within the NNC were much more likely reasons for the failure.

The NNC developed Magnox Reactor designs aimed at developing states. R.D. Vaughan of the NNC wrote that 300 MW Magnox reactors were aimed at states with grids of 1000 MWe.\(^{42}\) Indeed one such reactor, based on the twin station at Oldbury was suggested for Syria, and even Bangladesh. At the British Energy Show in Peking 1979 the Nuclear Power Company (a constituent of the NNC) the UKAEA and BNFL stressed the advantages of gas-cooled reactor technology for China.\(^{43}\)

Algeria was also a potential customer for British gas-cooled reactors even though it had not signed the NPT.\(^{44}\) Israel, Kuwait and Venezuela were also mentioned as possible buyers for Magnox or AGR systems.\(^{45}\) Unfortunately for the NNC other nuclear suppliers were also in the process of developing small reactors between 150 - 400 MW for states with small electricity grids. The objective here is to bring nuclear power within the reach of a wider range of developing states, and provide work for the beleagured nuclear industries. Kraftwerk Union, Alsthom - Atlantique and Hitachi all had such design projects in hand.\(^{46}\) Intense competition for a limited market could weaken the international safeguards regime as
the Swiss/German Argentinian deal adequately illustrates.\(^{(47)}\) Nevertheless it should be noted that this British export drive is not inconsistent with previous policy; rather it reaffirms a longstanding commitment to the export of the peaceful atom. Moreover, British governments argue that they are merely fulfilling their NPT obligations since Article IV, on civil uses of nuclear power, calls for due consideration for the needs of the developing areas of the world. Even though Ian Smart has criticised the nuclear industry for paying too little attention to the proliferation implications of reactor exports\(^{(48)}\), Whitehall in the end could prevent any sale if it was so desirous by withholding the necessary export licence. However, that nuclear deals were considered possible with three non-NPT states, Algeria, Chile and Israel, suggests that NPT membership is not the deciding factor.

In October, 1976 the Secretary of State for Energy accepted a NNC proposal that an assessment should be made of the three thermal reactors under consideration: AGR, PWR and SGHWR. The conclusions reached by the CPRS report on the Power Plant Industry in November 1976 provided an important reference point, "Britain does not have a nuclear system with export potential to offer".\(^{(49)}\) As the NPAB had done, the NNC reduced the choice to two: AGR or PWR. The SGHWR was excluded on the grounds that there could be no operational experience of commercial sizes for a decade and no chance of exports in the foreseeable future. Moreover, the NNC concluded:

If the principal purposes of this general choice of the two systems are to be achieved, the early adoption of the PWR has to be supported by a domestic ordering programme and by the recommended development work, and an AGR station has to be ordered and built, both of them in such a way as to help and not to hinder the UK export capability.\(^{(50)}\)
Once again export considerations played a major role in British thermal reactor policy. Neither the NNC or Government opposed the principle of reactor exports on non-proliferation grounds. This did not change in 1979 with election of a Conservative government. In its first statement on nuclear power in December David Howell noted:

The Government attach importance to the steady build up of the NNC into a strong and independent design and construction company, fully able to supply nuclear power stations efficiently at home and abroad.(31)

Although falling outside the scope of this study it is worth mentioning the Sizewell B Public inquiry which opened at Snape Maltings, Suffolk in January 1983. The inquiry examined the CEGB's proposals to build a PWR adjacent to the existing Magnox reactors. Discussion of exports at Sizewell emphasises the continuity of objectives and apparently irresolvable disputes over reactor choice; that is, which system is more likely to succeed in the export market. It should be noted that as before export considerations were by no means the most important factor, but rather one of the two or three principal issues. For instance, one of the arguments marshalled by the CEGB in favour of the PWR was made by the Board's Chairman, Sir Walter Marshall:

If customers around the world are buying PWRs then we have a better chance to sell them the reactors if we strive to sell them a PWR. That is an elementary law of business, that the customer is always right. So ... if you want an export business you must sell them PWRs.(52)

The NNC took a similar view, as did the DTI. Ned Franklin's proof of evidence of the inquiry makes this clear.(53). Even in 1976 and 1977 the UKAEA and sections
of the nuclear industry had reached this conclusion. The Authority noted that there was a strong argument that British future needs for thermal reactors should be met by the construction of PWRs built under licence. Moreover, the need to encourage the nuclear industry to work hard for export business "must inevitably" lead to an association with LWRs". (54)

The focus of reactor exports sales drive from Britain shifted away from OECD states towards LDCs. It is unlikely that reactors of any description could be sold to Western Europe states since they either have their own nuclear power programmes or have no need of one, Norway for example. This clearly has proliferation implications since the introduction of commercial nuclear power to new areas adds to the IAEAs difficulties in safeguarding fissile material. However, it is unlikely that the NNC will be in a position to export PWRs for the remainder of the 1980s. (55)

Failure to sell power reactors may be attributed to two factors. First, internal wrangles over reactor choice for domestic power programmes and the poor performance of the AGRs were particularly significant. Indeed the sale of a Magnox reactor to Turkey 1983 fell through because of internal disputes within the NNC. (56) Second, the dominance achieved by the LWRs in the crucial formative years of civil nuclear power worldwide, particularly within EURATOM, effectively precluded gas cooled reactors whether Magnox or AGR. Thus this failure cannot be attributed to fulfilment of Government non-proliferation objectives through a policy of denial. This was as much the case in 1982 as in 1958 the last time a British power reactor was sold overseas.

3. FUEL SERVICES 1971 - 1982

Whereas re-organizations of the reactor design and
construction industry did not lead to export success, the establishment of BNFL in 1971 did, or rather built upon the sound foundation laid by its predecessor the UKAEA Production Group. Throughout the 1970s fuel cycle service business prospered, conversion, fabrication, enrichment and reprocessing especially. Despite the failure of British gas-cooled reactors, BNFL successfully acquired fuel service contracts for LWRs.\(^{(57)}\) This is significant for two reasons. First, since the LWR was the dominant reactor system worldwide and the British domestic programme was then based on natural uranium fuelled Magnox Reactors, BNFL's export drive reflect a deliberate effort to expand scale of operations since the reprocessing requirements for the two fuels, oxide and Magnox are different. BNFL were no longer trying to fill excess capacity; on the contrary, as the thermal oxide reprocessing plant decision (THORP) demonstrates, it acquired business before the plant was built. Second, it indicates continued desire to make all types of nuclear services available for overseas customers. Success in the international fuel market would enable economies to be transferred to BNFL's domestic customers, the CEGB, SSEB, UKAEA and MOD. However, most of the overseas business came from OECD states.

Two significant events occurred during the 1970s in relation to fuel service exports and non-proliferation; first, the Windscale Public Inquiry into BNFL's plans to build a THORP at Windscale; and, second, the emergence of URENCO as a producer of LEU.

The last UKAEA Annual Report which referred to the fuel cycle services of the Production Group noted that:

Since .... 1954 the activities of these factories have greatly expanded as the name and commercial business of the Production Group has been developed to the point where the Group has established a leading position among the world's suppliers of
The Production Group had pioneered the international movement of commercial nuclear fuels and its successor, BNFL, intended to capitalise on this achievement of the mid 1960s. This was one, if not, the principal reason for the formation of BNFL in the first place. The UKAEA had a wide range of functions in the 1960s, nuclear weapon R & D, reactor R & D and fuel production. This led to managerial difficulties. Whereas the reactor and engineering sectors were not commercial the Production group was. An integrated management structure dealing exclusively with fuel business was more desirable given the overseas trade prospects which appeared substantial. It was reckoned that the Production Group's activities would be better conducted as a commercial business rather than a government company. From the outset it had an international view. BNFL's scale of operations can be established from the amount of fuel transported worldwide in the 1970s. For example, in addition to the movement of fuel to and from Europe and the United States, shipments have been made from the rest of the world including Australia, India, South Africa and Canada. Contracts in 1982 worth about £600 million involved the transport of 3500 tonnes of spent fuel. Dependent on this transport are separate orders for reprocessing worth over £100m. (59)

BNFL's policy objectives were clearly stated in its first Annual Report:

To meet the growth of the world demand in nuclear fuel products the company has made a sustained and vigorous marketing effort in all fields with special emphasis on those products and services which are not limited to a particular design of reactor. Business, particularly in the conversion of uranium concentrates to uranium hexafluoride and in the reprocessing of irradiated fuel has been extended and
It is instructive to look at the specific areas of the fuel cycle services BNFL provided in the 1970s as this gives a clearer picture of the pattern of trade in nuclear materials. A point to note, however, is that the form in which such materials are shipped are, in the main, unsuitable for direct and immediate use in a nuclear explosive. (61)

4. CONVERSION AND FABRICATION

By 1980 the scale of operations in conversion of uranium ore concentrates (UOC) to uranium hexafluoride (UF₆) were extensive. BNFL document Fuel Manufacturing Services noted that over 20,000 tonnes of UF₆ had been delivered to the US Department of Energy's enrichment plants on behalf of overseas customers. (62) The Springfields modern conversion plant produces extremely pure UF₆ which "easily meets the feed specifications for enrichment plants throughout the world". (63) Springfield's modern "hex" plants enable BNFL to achieve low costs thus facilitating successful competition on the world market. (64) In 1972 BNFL produced twenty percent of the total volume of UF₆ gas in the western world. (65) Such was the level of overseas business in 1978 that a programme to expand Springfield's capacity was started. BNFL still accounted for about twenty percent of the market. (66) In 1972 BNFL earned £1m for UF₆ from the West German Utility Kernkraftwerk Phillipsberg GmbH. (67) An even larger contract was won from Spain; this was reported as being worth £15 million. It covered a substantial portion of Spain's nuclear power programme requirements. The UF₆ was to be delivered to US enrichment plants between 1978 and 1983. (68) Despite this Foreign Office officials were reported to be worried that a loophole will open up when Spain joins the EEC in January 1986. With membership goes access to nuclear materials and technology under the EURATOM Treaty. (69) Spain, however,
is the only European non-nuclear weapons state which has not signed the NPT. The FCO view is surprising when we consider that the UKAEA had contracts with Spain dating from the 1960s. Non-NPT states have not been excluded from access to Britain's nuclear services.

In 1981, the Springfields plant was expanded again to meet the overseas demand. The company was also interested in supplying UF₆ conversion technology which is much more serious from the non-proliferation point of view. Nevertheless there was worldwide interest in BNFL's conversion technology. Indeed BNFL participated in a number of joint feasibility studies with overseas interests with a view to constructing UF₆ conversion plants when market conditions justified expansion. BNFL has licensed users in Europe and the United States to use the Integrated Dry Route Process in which enriched UF₆ is converted in one stage to oxide by reaction with steam and hydrogen. UF₆ plants for Brazil and South Africa were also under consideration; however, these never went ahead. The South African proposal was vetoed by the British Government which caused BNFL a great deal of pain since the French provided assistance instead. By 1983 BNFL had provided UOC/UF₆ conversion services to Australia, Austria, Belgium, Brazil, FRG, Italy, Japan, Netherlands, Spain, Sweden, Switzerland, Taiwan and the US. Export sales had increased fourteen times over the equivalent figure in 1973/74, and represented one of BNFL's major successes. Magnox fuel elements for Italy and Japan continued to provide a steady source of income. Some oxide fuel was also supplied to the Netherlands.

5. URENCO AND ENRICHMENT

In addition to URENCO the British also participated in a joint study programme with EURODIF, the French led gaseous diffusion consortium, but withdrew in the early 1970s convinced that the gas centrifuge would provide the
The small pilot plants at Capenhurst and Almelo produced the first LEU, and were completed between 1972 and 1976. During 1973 a decision was made to construct two 200 te/SW plants, one at Capenhurst and the other at Almelo. By 1977 URENCO had already secured firm business in excess of 2000+/SW for delivery in the early 1980s and beyond. Although the 300 SWU plants were officially opened in 1978, the first cascades were not on stream until the end of 1980. The gaseous diffusion plant at Capenhurst was also used to produce LEU.

The gas centrifuge's principal attraction from a commercial perspective is that additional tranches can be built quickly whenever the market appears to be expanding. Moreover, it consumes less than ten percent of the energy input for the same amount of production as the gaseous diffusion process. In other words centrifuge technology is more appropriate and responsive to the needs of an export market than a gaseous diffusion plant. The first eight cascades at Capenhurst went into operation in 1977 with a total capacity of 50 te SWU. Additional cascades were to be installed at a rate of approximately one every six weeks until full capacity of 200 te SWU per year was reached. Because of market conditions the completion date was put back from 1979 to 1980.

One of URENCO'S objectives was to break the US monopoly on the supply of LEU. The unilateral US declaration in 1974 of a cut-off in supply confirmed the dangers of over dependence on an unreliable supplier. This was to URENCO'S advantage. In 1980 three West German utilities cancelled enrichment contracts with the US Department of Energy and placed a substantial order with URENCO. There were basically three reasons for this; first, there was a general wish to reduce dependence on foreign sources of supply; second, the perception that the US could no longer
be regarded as a reliable supplier(81); and third, West German participation in URENCO and plans to build an enrichment plant at Gronau in the FRG cannot be excluded.

In 1981 URENCO produced 158 tons of LEU of which 72 te was produced at Capenhurst and the remainder at Almelo. Most of this was destined for use in the CEGB/SSEB AGRs, the balance for utilities in the FRG and Netherlands, Switzerland and Brazil.(82) Provision of LEU to a non-NPT state such as Brazil is illustrative of British attitudes to the proliferation question. In 1975 the FRG concluded one of the largest nuclear deals ever, between £25-30 billion, with Brazil.(83) Kraftwerk Union would supply power reactors; however, enrichment, fabrication and reprocessing technology would also be supplied. This would enable the Brazilians to close the nuclear fuel cycle and achieve virtual nuclear independence. But there would be a gap of several years before the enrichment plant became operational, especially since it was based on an unproven technology. Until then Brazil would require LEU for its LWRs. To this end Brazilian authorities approached URENCO in 1976.(84) Although the British Government was unhappy with the original FRG/Brazilian contract, it agreed to business with Brazil. Consequently URENCO was awarded a ten year contract for the supply of enriched uranium. URENCO won the contract for three reasons. First the German nuclear deal at 1975 paved the way for further German involvement; second, Britain had longstanding nuclear contacts with Brazil since the 1960s; and finally, US reliability and hostility to Brazil's nuclear power programme counselled against buying from ERDA.(85)

Although the first delivery of fuel was not until 1981, the Dutch Parliament had misgivings since Brazil had not signed the NPT. Consequently, it retained the right to veto the contract; however, plans to build the first West German commercial plant at Gronau were accelerated. Both the British and Germans were keen for the deal to
proceed.(86) BNFL even considered expanding capacity at its Capenhurst plant to meet the 2000 tonne order.(87) It seems that the British felt that reliability and assurance of supply were important considerations. Unreliability world damage URENCO's reputation as a supplier which might encourage states to develop indigenous enrichment capability. Brazil could only be induced to accept the international non-proliferation regime by persuasion. Denial of a legitimate energy security request would have the opposite effect: Provided adequate safeguards provisions could be negotiated there was no reason for the Government to prevent URENCO meeting the Brazilian order.(88) Brazil, however, was not prepared to accept full-scope safeguards. As noted in Chapter 10 the British Government would only insist on full-scope safeguards if all other suppliers required them. If the UK insisted on FSS without other suppliers imposing identical conditions, contracts would be lost to less scrupulous suppliers.

The Brazilian contract was confirmed in December 1982 in a written Parliamentary answer given by Minister of State, Department of Energy, John Moore.(89) But URENCO was not content with just Brazilian business as Moore makes clear:

URENCO is actively seeking export orders from the operators of civil nuclear power stations. The Capenhurst plant will undertake the enrichment work allocated to it by URENCO Ltd. Overseas contracts are subject to the approval of the Governments of the United Kingdom, the Federal Republic of Germany and the Netherlands.(90)

URENCO had contracts worth £1300m for overseas customers for delivery into the 1990s. Of this BNFL accounted for about £433 million.(91) In 1981 BNFL's Annual Report noted that the order book had expanded to £1500M with Capenhurst again accounting for roughly a third of the business.(92) A second centrifuge plant with a projected capacity of more
than 800 tonnes SWU per annum was scheduled to move into full production by 1983. BNFL's Chairman Sir John Hill attributed URENCO's success to the benefits derived from tripartite co-operation. Hill argued that there are real non-proliferation benefits arising from the multinational approach to the production of nuclear fuel services. (93) Despite this observation the principal reason for URENCO's existence was commercial.

Given the competition for enrichment services between URENCO, EURODIF, the US Department of Energy and Techsnabexport of the Soviet Union, flexibility in operations is the key to success. In this respect the centrifuge is well suited. Modular construction enables additional tranches of centrifuges to be added in the time between awarding of contracts and their delivery dates. This has enabled expansion to be achieved gradually in accordance with URENCO'S delivery commitments. Equally important was the ability to incorporate new designs and improvements. As T. Edwards of BNFL's Enrichment Projects Designs Office notes:

This flexibility is necessary to ensure that URENCO maintains its position as a serious commercial supplier of enrichment. (94)

Moreover this flexibility:

offers the recipient a high degree of supply assurance. The gradual build up of capacity and the short-time within which capacity can be expanded make it possible to match supply and demand with some precision .... Assurances of continuous supply are reinforced further by decentralised production in the UK and Netherlands and in future in the Federal Republic. (95)

Assurance of supply was identified by INFCE as a useful
mechanism for a coherent, and mutually acceptable for customer and supplier, non-proliferation strategy. This is basically what Sir John Hill had in mind.\(^{(96)}\). Indeed Wansink's conclusions would be endorsed by Whitehall, "Non-proliferation is closely connected with the principle of assured supply. The flexibility of the technology employed, the de-centralization of production and a consistent and predictable export policy help to give assurance of supply".\(^{(97)}\) However, URENCO was not organised for these reasons; rather, as URENCO and centrifuge technology developed it became clear that there were non-proliferation benefits to be derived from both the technology and multinational organisation. For the British American unreasonableness and unreliability had been a crucial factor in the formation of the consortium in the first place.

CENTEC continued to reduce progressively the specific cost of the centrifuges in order to "ensure that URENCO maintains its position as a leader in the commercial supply of enriched material".\(^{(98)}\) These advances would maintain the competitiveness of the project. Exports are, therefore, not required to employ excess capacity as tended to be the case with fuel services in the 1960s; rather, enrichment business was sought before the capacity was built.\(^{(99)}\) In 1979, for example, when URENCO's order book amounted to some £1300M, additional business led to the order for a second and larger centrifuge plant at Capenhurst.\(^{(100)}\) The central features of URENCO's approach, no stockpiling, no overproduction and no redundant plant unlike the US DOE or EURODIF, allowed the company to be the only enricher with, "fully utilized plants with 2 continuing programmes of expansion to meet orders, and with a sequence of technology developments far stepwise introduction as and when they are proven throughout the next decade".\(^{(101)}\) Although most of URENCO'S orders were from Europeans, its "main marketing effort is outside. We have our eyes on all parts of the world like everybody else" noted URENCO's commercial
Director Johannes Asyor. The main target, however, was the US market which was potentially the most lucrative; for example, in 1978 URENCO officials made the rounds of several US utilities to persuade them of URENCO's advantages. Toll enrichment which only produces 3-5% U235 is not a major proliferation risk. It should also be noted that BNFL seem to take the view that provision of fuel services such as LEU do not constitute a major proliferation risk given the nature of the material. Reactors and fuel plants pose a much greater hazard; therefore, by providing fuel services BNFL reduces the incentives for states to construct indigenous plants. But exports of centrifuge technology pose a much greater risk. In 1982 a group of Australian companies, which had studied the competing world enrichment technologies on behalf of the Australian Government, chose URENCO/CENTEC's centrifuge as the most promising and reliable. The next phase called for a detailed joint feasibility study. Discussions had taken place in the early 1970s on the possibility of locating a commercial enrichment plant outside Europe. Indeed Australia was regarded as an ideal location for capturing the Japanese market for enriched uranium. As a NPT state with a good record of accepting and promoting nuclear safeguards there was clearly no problem with any transfer of centrifuge technology, albeit under licence, to Australia. It is not so much a case of sensitive technologies, but rather of sensitive countries. In other words such decisions are based on political judgements, not technological sensitivity.

URENCO had delivered 2 million SWU to customers by March 1983, mainly to customers in the FRG, Netherlands and Brazil. Outstanding orders totalled about £3 billion. BNFL's share in earnings was not insubstantial, in 1982/3 toll enrichment represented about 25% of BNFL's export earnings.
6. REPROCESSING, UNITED REPROCESSORS AND THE WINDSCALE PUBLIC INQUIRY

Spent fuel reprocessing and its transportation became BNFL's most profitable business. Indeed the Production Group had pioneered the worldwide transportation and reprocessing of oxide fuels. BNFL's decision to build a thermal oxide reprocessing plant (THORP) at Windscale, which would be partly financed by export contracts, was the major reprocessing event of the decade. Moreover, the inquiry also illuminated British thinking on non-proliferation. Although the expected reprocessing business envisaged in the 1960s did not materialise, it was nonetheless still profitable. The Economist, for example, estimated that the spent fuel from more than one hundred European and Japanese reactors could amount to £2 billion by 1990. (108)

The 1970s witnessed the development of plans and objectives outlined in the 1960s. As Wynne notes plans were laid for reprocessing overseas fuel in 1967 which even then was regarded as a "highly attractive commercial proposition where Britain could recoup some of the investment poured without return into the reactor side". (109) But as we have seen in Chapters 4 and 5 the origins of this decision are in the late 1950s. Motivations then, as in the 1950s, were primarily commercial.

By 1973 the Production Group and its successor had reprocessed oxide fuel from Canada, Federal Republic of Germany, Italy, Japan, Spain and Switzerland. About 321 tons were reprocessed for overseas customers with a distribution as follows: Japan 144, Italy 122, Switzerland 30, FRG 14, Spain 11, Sweden 5, Canada 2 and Belgium. (110) Furthermore of the 70,000 tonnes plus of spent fuel BNFL planned to reprocess by the year 2000 as much as one third was expected, in 1975, to be for overseas
customers.\(^{(111)}\) Japan was seen as the principal customer. The UKAEA had a long standing association with Japan going back to the 1950s. For BNFL, Japanese contracts were important as they would finance the expansion of reprocessing operations. In October 1974 BNFL started to negotiate on behalf of URG with thirteen Japanese companies for reprocessing.\(^{(112)}\) At the end of August 1975 a team from Enrichment Reprocessing Group (ERG) Japan came to London to negotiate reprocessing terms. BNFL sought £334 m in return for reprocessing 4000 t of fuel over a ten year period.\(^{(113)}\) However, the British Government had to decide whether to authorise further overseas reprocessing business. But it seems that Government deliberations had more to do with environmental considerations such as disposal of medium and high level waste, than with any proliferation considerations. In the end approval was given in March 1976.\(^{(114)}\) However, the Secretary of State for the Environment Peter Shore decided to hold a public inquiry into BNFL's THORP proposals.

The 100 day Windscale Public Inquiry will only be discussed here in so far as it relates to the reprocessing of foreign fuels, primarily Japanese, and to nuclear proliferation. BNFL sought to finance the expansion of its operations from export earnings. A customer, as part of the contract, would pay for the construction and operation of the plant in addition to the transportation and reprocessing. For instance, BNFL wanted the Japanese to make a 40\% down payment on the approximately £800 m contract and pay another 40\% upon completion of reprocessing.\(^{(115)}\) The proposed expansion was described thus:

In addition to the new 'home' plant, a proposal has been put forward for a second identical plant to provide capacity for potential overseas reprocessing business - principally a 4000 tonne contract from Japanese utilities but also 2000 tonnes under
discussion from other countries. The second new plant, which is referred to as the "overseas" plant (although in practice arisings of fuel will not necessarily be segregated in this way) is proposed for operation by about 1987. The contractual terms that are being negotiated for the overseas business include a provision for down payments which yield most of the money needed to build the plant ... the need for a decision on the "overseas" plant is now urgently called for by BNFL in order to clinch such a contract.\(^{(116)}\)

Unfortunately for BNFL US non-proliferation policy had undergone a considerable change during the Ford Administration. This was carried on with more enthusiasm by the Carter Administration of 1977-1980. The US now proposed that commercial reprocessing should be deferred lest it contribute to proliferation; furthermore, the Administration was prepared to veto the transfer of oxide fuel, which had originated in the US, for reprocessing. This threatened Japanese nuclear plans as well as those of BNFL. Japan had long considered nuclear power vital to its energy security. The 1973 Middle East war and its effect on oil supplies and prices confirmed the desirability of such a policy. Japanese utilities hoped to have 3270 tonnes of spent fuel reprocessed between 1982 and 1990. URG were keen to accept, and preliminary negotiations proposed to divide the work between BNFL and COGEMA whereby each would take 1635 tonnes.\(^{(117)}\) Indeed URG aimed to expand its operations and engaged in talks with European utilities to this end. As with Japan URG sought firm reprocessing contracts combined with advance payments from the utilities to help finance the heavy investment costs.\(^{(118)}\)

President Carter's hostility to reprocessing in general and THORP in particular threatened a highly lucrative business. Indeed the Environment Secretary's decision to hold a
public inquiry was also seen as a potential setback. Con Allday, BNFL's Managing Director, warned that such a decision could lead to loss of the Japanese contract but if "we can have an inquiry that does not take too long then we could still retain the business". More significantly, however, once the inquiry was underway the Department of Energy argued that urgency was crucial since non-proliferation grounds counselled for avoidance of further uncertainty in the minds of customer countries as to the UK's intentions. Provided an early decision could be made within first two months of 1978, Allday was "not too worried"; however, the delay hampered negotiations with European utilities. They decided that they would talk to the French until such times BNFL was in a position to sign a contract. The British position represents a mixture of commercial self-interest and non-proliferation objectives; however, the former was the principal reason for THORP. Reliability as suppliers of fuel services would reduce incentives for states to build their own fuel plants.

Once the Inquiry opened BNFL argued that export earnings were a ready reason to proceed with THORP. A contribution of at least £600 million in foreign currency could be made to the balance of payments. Lest US opposition to reprocessing prevent the Japanese contract from being concluded, the Secretary of State for Energy, Tony Benn, offered his assurance to the Japanese utilities that Britain was keen to have the business; and would, furthermore, try to convince the US Government that safeguard provisions were adequate. Moreover, both the Prime Minister and Foreign Secretary, David Owen suggested to President Carter that Britain ought to take the Japanese fuel. Rather than undermine non-proliferation objectives, provision of assured supplies would strengthen the international non-proliferation regime. For example, in a major policy statement at Chatham House Owen noted that if reprocessing were to occur, it should do so in as
few countries as possible, namely the existing NWS. (124) Furthermore,

We need also to ask ourselves whether, if there are countries who cannot do without reprocessing, they would not be driven to develop their own facilities from existing technology, should countries like Britain and France withdraw reprocessing services they now offer to others. (125)

BNFL latched on to this as a useful argument in favour of further reprocessing business. (126) Thus the Company's corporate interests could be identified with the furthering of non-proliferation objectives. At the WPI Christopher Herzig, Head of the Atomic Energy Division in the Department of Energy, noted that the US policy of denial between 1946 and 1953 led to other nations developing their own military nuclear capability, including Britain. (127) Moreover, denial of reprocessing services would stimulate states to acquire their own reprocessing technology. (128) British experience is particularly important here since US policy had only encouraged an independent British nuclear programme and a European enrichment project in the 1960s. Con Allday argued that if the UK were to forego the reprocessing option it would not prevent other states from reprocessing their own fuel; furthermore any state determined to build nuclear weapons would not choose to divert materials from a commercial reprocessing plant, it would instead build dedicated facilities. (129)

Pearce, Edwards and Beuret argued that:

the interpretation of the NPT in the Windscale Public Inquiry suggests that the principal question asked was, in effect "can the NPT be read in such a way as to justify a UK reprocessing plant". (130)

However, the evidence suggests the contrary; this had
always been Britain's understanding of the Treaty. Justice Parker in his report merely pointed to British obligations as a major reason for THORP to go ahead. Parker's Report notes that:

Since (i) there will be no direct risk arising from THORP for at least ten years (ii) to deny reprocessing facilities would be against the spirit and as I think the letter of our obligations under the main existing bulwark against proliferation (iii) to deny such facilities would create an immediate incentive to others to develop their own facilities (iv) there is a world need for adequate reprocessing facilities somewhere, it appears to me that a grant of permission would have a non-proliferation effect rather than the reverse. I do not accept that the best way to achieve a new bargain is to break an existing one. (131)

Dr Owen had also noted that "judged overall politicians have allowed the urgency and dangers of the proliferation problem to be swamped by commercial interest and bureaucratic indifferences". There was nothing inconsistent in BNFL's THORP proposals with previous policy. Even though Dr Donald Avery, BNFL thought that Owen's remark was fair comment(132), acquisition of fuel business had been an objective of the Production Group well before the NPT was signed in 1968. Avery's colleague Con Allday admitted that BNFL's reasons for wanting to proceed with the Japanese deal were "frankly purely commercial". Nevertheless, Avery went on to note that the proliferation question was not ignored; on the contrary, the energy security benefits of reprocessing and non-proliferation objectives were not incompatible. (133)

Parliament voted in favour of THORP in March 1978. The contract with Japan, worth £500 million(134) was agreed on 24 May and BNFL was to receive 1600 tonnes to be
delivered between 1982 and 1990. THORP was designed to have a capacity of 1100 tonnes per year and was expected to earn £900 million from overseas contracts of which £600 million was for reprocessing, the remainder for transportation costs. The benefits to fuel costs of the CEGB and SSEB were not insignificant; for example, it was estimated that the saving to UK generating boards by having a larger reprocessing plant with foreign business would be in the region of £65 m to £165 m. During the Inquiry BNFL's Reprocessing Division negotiated further contracts with Swedish, Swiss and West German utilities.

In the 1981/82 financial year BNFL earned £409m in reprocessing and transportation contracts. This compared with £1.2 m in 1971/72. Such services were supplied to Belgium, Canada, France, FRG, Italy, Japan, Netherlands, Spain, Sweden and Switzerland. Indeed in 1982 BNFL offered to reprocess another 900 tonnes of foreign fuel in THORP because the needs of the CEGB and SSEB were less than expected. BNFL experienced no difficulties in filling the capacity as it was oversubscribed several times.

7. FUEL SERVICES: CONCLUSION

Throughout the 1970s BNFL proved itself a success. It is one of the world's major suppliers of fuel services. Unlike the fragmented reactor industry, BNFL is a single company with clear objectives which is a major factor in its success. BNFL's objectives are primarily commercial. The company does not make British non-proliferation policy, that is a matter for the Government. Indeed BNFL would not have it any other way. It cannot conduct business without Government authority, but tries to avoid a situation in which a customer is turned down after initial enthusiasm on account of Government action. For this reason the company prefers clear guidelines and a stable environment in which to conduct its overseas business. However, BNFL is not an export led organisation. Despite the scale of its
operations BNFL does not consider the supply of LEU, UF₆ or reprocessing as a significant proliferation threat; on the contrary, it is much better to provide reliable service to overseas customers. This is sensible commercial practice which incidentally may further non-proliferation objectives since it reduces the incentives for countries to build their own plants.

8. CO-OPERATIVE AND COLLABORATIVE AGREEMENTS 1971 - 1982

URENCO and URG were the most important co-operative ventures in the period. Both had broadly similar objectives, URG, for example, was intended to provide a reliable long-term reprocessing service for utilities worldwide. In addition to these organisations BNFL had shares in five other international companies two of which were formed in the 1960s. Nuclear Transport, for instance, was incorporated in England in 1972 for the purpose of providing services for the transport of irradiated fuel elements from oxide fuelled power reactors to reprocessing plants. In other words the trend towards specific goals in co-operation and collaboration agreements rather than general R & D was confirmed in the 1970s, Sir John Hill noted that:

In the early days collaboration was concerned primarily with exchanging information of a research and development nature. As the industry developed so the nature of collaboration changed to reflect not only growing commercial interests, but also the high development costs, technical complexity and great size and cost of nuclear installations...

The UKAEA continued its promotional activities overseas. In particular, the Authority's reactor services and fuel services for experimental fast reactor and other advanced reactor systems were particularly successful. Irradiation space in the Dounreay Fast Reactor...
was made available to overseas nuclear interests.\(^{(144)}\) In 1977 the UKAEA reported that it had "made major efforts to support British companies who are seeking overseas consultancy or construction contracts on nuclear projects".\(^{(145)}\) In addition there was considerable international collaboration on fast reactor R & D between leading European states.\(^{(146)}\) UKAEA Chairman Sir John Hill considered such collaboration as vitally important. An agreement could have been concluded with France in 1974 had the Energy Secretary not vetoed it.\(^{(147)}\)

Middle Eastern states figured prominently in the Authority's promotional campaign. Advice was given to Iran on safety requirements for a developing nuclear power programme, and prior to the fall of the Shah in 1978 the UK expressed an interest in Iran's proposed nuclear power programme.\(^{(148)}\) The Authority also advised the Kuwait Ministry of Electricity and Water on the acquisition of a training reactor.\(^{(149)}\) The objective of these contacts is to ensure that the resources of the Authority and the British nuclear industry are brought to the attention of those who are planning nuclear programmes.\(^{(150)}\) The clearest statement on the need for overseas work and its relationship to the domestic programme was made in the 1973/74 UKAEA Annual Report:

The objectives of the commercial overseas work are:

(i) to offset the cost of nuclear power development by selling capacity in facilities which have to be maintained for the UK programme. (ii) to develop services which might ultimately be provided by industry but which require the backing of skills, technologies and equipment at present vested in the Authority. (iii) to establish contracts with overseas countries which might later be available to industry.\(^{(151)}\).

It is clear that both UKAEA and BNFL remained committed to
the worldwide spread of nuclear power and knowledge. Collaborative R & D agreements were a means to a clearly defined end: business for British nuclear industry. This was made clear by Peter Hirsch Chairman of the UKAEA in 1983.\( ^{(152)} \)

CONCLUSION

The relationship between international collaboration, URENCO and URG in particular, and British non-proliferation became clearer in the late 1970s. Indeed non-proliferation considerations played a part in the original decision to establish URENCO, but this was not made public until the 1970s. BNFL and Production Group fuel business objectives were largely commercial, and not conditioned exclusively by non-proliferation considerations. In short, Multinational/Regional Fuel Cycle Centres (M/RFCC) concepts were examined in the mid 1970s after URENCO and URG had been established. Both, however, provided useful models but commercial rather than non-proliferation objectives were the reason for their existence. Con Allday makes this clear:

> In forming the URENCO/CENTEC and United Reprocessors, although the motives of participating organisations were essentially commercial, political pressures, particularly those concerning non-proliferation, have had a major influence on the policies of both organisations.\( ^{(153)} \)

Nevertheless, as Allday went on to observe, it seems that for the British at least prevention of, or rather reducing the risks of nuclear weapons proliferation, requires that both the supplier and customer states work together to develop realistic and acceptable policies. There was thus a blending of commercial and security interests. Assurance of supplies suited both BNFL and its customers, but also strengthened the international non-proliferation regime by providing a stable and predictable framework for nuclear
trade. Consequently the interests and objectives of British civil nuclear programme and non-proliferation policies were not mutually exclusive; rather, they were complementary. A combination of factors including commercial interest; historic experience, the pre 1953 years in particular, multinational nuclear fuel cycle arrangements, shaped British non-proliferation policies in the 1970s.

Although no power reactors were sold in this period, BNFL's fuel cycle services expanded and prospered.(154) BNFL, however, was not an export led company. There was also a successful trade in reactor components, for PWRs in particular. In short, the British were as committed to the Atoms for Peace principles as they had been in the 1950s. Towards the end of the 1952 - 1982 period provision of fuel services for overseas customers became increasingly linked with non-proliferation policies. The British saw a confluence of interests here: non-proliferation objectives could be fulfilled by providing nuclear fuel to NNWS which would remove their incentives to build their own sensitive fuel cycle plants since the UK's fuel business expanded in the 1970s, it seemed sensible to make a virtue out of commercial necessity. Despite the delays in the domestic programme, nuclear power was regarded as essential for British energy security. If this was true for comparatively energy rich states like the UK, then it applied as much to other states. For this reason maintenance of stability and predictability in the international nuclear fuel market would safeguard the legitimate energy requirements of states such as Japan. This was clear at WPI, unreliability and uncertainty could lead to additional sensitive fuel cycle plants worldwide. From the British perspective the fewer enrichment and reprocessing plants the better. Instead URENCO and URG would provide the necessary services. However, the flaw here is that the British had themselves sought fuel cycle independence for strategic reasons. This was one of the
reasons for URENCO. The risks of dependence on an unreliable supplier were key factors in the formative years of nuclear energy in Britain. The same conclusions were drawn by Argentina, India and Pakistan since all three have sought to close the fuel cycle and thus secure a greater degree of nuclear independence. (155)
CHAPTER 7

UK FAST REACTOR DEVELOPMENT AND PROLIFERATION

1. INTRODUCTION

Fast reactor research had become by 1982 the single most important activity of the UKAEA. From the proliferation perspective a reactor which both burns and produces plutonium is particularly sensitive. This is because weapons grade plutonium, containing 90% plus of the fissile isotope Pu.239, is present in the fast reactor fuel cycle. Despite this there is, in the British case, a relationship between the rationales for fast reactor R and D and British non-proliferation strategy. This relationship became particularly pointed in the late 1970s. It appeared as if British non-proliferation objectives could best be achieved by actually encouraging the deployment of commercial fast reactors. However, it is not altogether clear whether this was an after-the-fact rationalisation for a project which would have been pursued irrespective of other considerations, or a pragmatic response to a pressing problem. Available evidence would suggest that the former was the case. For example, it has been observed that within decision-making structures the potential dangers of a plutonium economy tend to be viewed as less troublesome than the dangers of interruptable and/or high cost foreign energy supplies.\(^1\) It is not clear, however, whether the avoidance of these disadvantages is necessarily at odds with a non-proliferation strategy based on fast reactors. This chapter will seek to identify the relationship between domestic British nuclear policy and non-proliferation policy. Four areas need to be discussed. These are: brief technical description of the fast reactor; history of fast reactor R and D within the UKAEA; rationales and objectives of the reactor programme; and relationship between a programme emphasising energy security and non-proliferation objectives.
2. TECHNICAL CHARACTERISTICS

It is not necessary to provide here a detailed technical description of fast reactor technology. A brief overview of its essential characteristics will suffice.\(^2\) A fast reactor initial fuel load consists of a core of mixed uranium-plutonium oxide fuel. The core is surrounded by a "blanket" of natural uranium oxide. When the reactor is operated the heat produced by the fission process is removed by liquid sodium via heat exchangers. The transferred heat is used to raise steam which in turn drives the turbines. Unlike thermal reactors there is no moderator. A thermal reactor is so called because the neutrons that cause fission are slowed down by collision with a light element (moderator) in the core of the reactor. A fast reactor uses high energy neutrons. The word 'fast' does not refer to the reactor's capacity to breed plutonium. During the operation of the fast reactor there is a steady net incineration of plutonium in the core. However, the neutrons which escape from the core are captured by the U-238 blanket. This produces more plutonium via the

\[
\text{n gamma} \quad \text{U}^{238} \quad \text{beta} \quad \text{NP} \quad \text{beta} \quad \text{U}^{239} \quad \text{PU}^{239}.
\]

\[
23.5\text{m} \quad 2.35\text{d}
\]

The rate of production, however, depends on the design of the reactor itself and how it is operated.\(^3\) In the model reactor discussed by Dr. Marshall in his 1980 Atom article the initial quantity of plutonium fuel is 1936kgs. After a year's operation plutonium production is only 1750kg. This represents a loss of 231; however, if a U238 blanket is incorporated the reactor will produce 421kg. Overall the balance of plutonium produced is 190kg.\(^4\) This figure is much lower when compared to that of thermal reactors of similar sizes. Despite this the reactor can become self-sustaining since it will eventually produce sufficient plutonium to provide the initial inventory required for a new reactor. It is this possibility which leads to the
name "breeder". Finally, by using uranium 238 in the blanket more efficient use can be made of uranium reserves. In a thermal once-through fuel cycle only a fraction of the energy of uranium fuel is used. The U238 which would be used in the "blanket" is a waste product from the enrichment and reprocessing plants of the thermal fuel cycle. There are, according to Marshall, six key characteristics of fast reactors:

(i) They do not breed fast  
(ii) Use fast neutrons and breed slowly  
(iii) mostly they incinerate plutonium  
(iv) core is an incinerator  
(v) blanket (optional) is producer  
(vi) the balance between incineration and production is delicate.\(^5\)

Fast reactors are therefore fundamentally different from thermal reactors. There are, however, significant technological and engineering difficulties involved in their construction.\(^6\) Furthermore, the economics of fast reactor construction and operation are highly contentious. UKAEA officials assert one thing whilst the anti-nuclear movement equally confidently assert the opposite. Environmental and safety questions produce equally partisan responses from the anti-nuclear movement and nuclear industry. However, as these issues do not impinge directly on the proliferation question they will not be addressed here.

3. FAST REACTOR RESEARCH AND DEVELOPMENT IN THE UK

From the beginning of atomic energy research in Britain scientists at the Atomic Energy Research Establishment, Harwell realised that the fast reactor was the ultimate, and logical, aim for any nuclear power programme. For example, the first reference to fast reactors in the archives occurs in 1946.\(^7\) As Margaret Gowing notes it
was generally agreed that in the longterm the fast reactor would be the best method of producing electricity by nuclear power.\(^{(8)}\) Gowing again notes that they were given first priority by the Ministry of Supply's Technical Committee and by the Atomic Energy Council when reactor policy was discussed in 1949-50, and again in 1952.\(^{(9)}\) Despite this recognition there was a more sober estimation of the likely date when fast reactors would produce commercial electricity. Twenty-five to thirty years from 1945/6 was thought to be the most likely time scale.\(^{(10)}\)

It was not until the 1950s that development work on the reactor assumed concrete form.\(^{(11)}\) Construction of an experimental fast reactor was first considered in 1951, but authority for an engineering design was not given until 1954. The following year construction work started at Dounreay near Thurso, and the reactor went critical in November 1959.\(^{(12)}\) The reactor was scheduled to start-up on 1 April; however, in the aftermath of the Fleck Committee's report on the staffing of reactors following the Windscale fire, personnel were taken off the Dounreay project so that the defence work would not suffer.\(^{(13)}\) Moreover, given the pressures on fissile material at this time, plutonium in particular, the fast reactor had to take second place.

Between 1954 and 1958 physics experiments with a plutonium-fuelled zero energy facility, ZEPHYR (Zero Energy Fast Reactor) at Harwell had confirmed the breeding potential of the fast reactor system. Additional design and operational information for the Dounreay reactor was provided by a zero energy uranium system - ZEUS - also at Harwell. The core of this research reactor was closely related in design to the Dounreay reactor.\(^{(14)}\) Moreover, its HEU fuel was subsequently transported to Dounreay for use in the fast reactor which was termed the Dounreay Fast Reactor - DFR.

It was not until 1963, however, that the DFR became fully
operational, but it did demonstrate the engineering feasibility of the fast reactor concept designed by Harwell. The UKAEA also constructed a fuel reprocessing plant which was completed in 1961. The objective was to gain experience with the fast reactor fuel cycle. Ultimately it was planned to close the fast reactor fuel cycle. From 1966 onwards the UKAEA used the DFR as an irradiation test facility for overseas customers earning about $9.5 million.\(^{15}\) In August 1975 the UKAEA announced its intention to close the DFR in October 1976. The reactor was finally shut down in March 1977. During its seventeen years of operation it had generated almost 600 million units of electricity for the grid.\(^{16}\)

Authorisation for the construction of a 250MWe prototype fast reactor, as well as fuel production facility at Windscale, was given by the Minister of Technology, Frank Cousins, in February, 1966. This reactor was designed according to the advanced reactor technology of the mid 1960s and incorporated the lessons learned from its predecessors. According to Hill and Franklin the research objectives were to assist in the development of breeder reactors of larger size, improved economy, high reliability and availability.\(^{17}\) The reactor was expected to come on power in late 1972; however, by 1969 the timetable was delayed by difficulties encountered in welding the biological shield roof.\(^{18}\) Electricity was not supplied to the North of Scotland Hydro Electricity Board until April 1975. The achievement of high power and continuous generation of electricity was delayed by leaks in the steam plant.\(^{19}\) By 1976 the fast reactor employed the greatest share of the UKAEA's resources.\(^{20}\)

By the end of 1981 the PFR had reached a degree of reliability, although there were still difficulties with the steam generators. Indeed the principal problems lay not with the basic nuclear technology, but rather with the
conventional engineering technologies. The PFR, for instance was dogged with problems with its generation plant.\(^{(21)}\) In 1982 the reactor and its fuel had continued to perform satisfactorily, but again it was the conventional technology, this time leaks in the boilers' evaporator units, which undermined station operation.\(^{(22)}\)

As mentioned above, the associated fuel cycle facilities developed in tandem with both the DFR and PFR. In 1973 the UKAEA decided to construct a spent fuel reprocessing plant by modifying and adding to the existing plant at Dounreay. This was regarded as the next step in closing the fast reactor fuel cycle.\(^{(23)}\)

It is important to note that neither the DFR or PFR were built purely for the sake of research. For the UKAEA these reactors were the test bed for a future programme of commercial fast reactors. CFRs would, in the view of the UKAEA, ultimately form the basis of nuclear power in Britain.\(^{(24)}\) However, the timing of their introduction continued to slip back throughout this period. The reference design was a pool-type reactor rated at roughly 1300 MWe. By 1982 no such reactor had been built. The most likely date for its introduction was put off until the 21st century. More will be made of this in the next section.

Despite this the UKAEA at the end of the 1970s had identified three objectives for its fast reactor R & D leading to the development of a commercial reactor. These were:

(i) To demonstrate the economy and reliability of the reactor plant and of acceptable fuel cycle operations;

(ii) to establish the safety features which will enable a reasonable number of sites to be
considered;
(iii) to illustrate as realistically as possible the favourable impact of the ability to build power fast reactors on the future of British energy costs, availability and trade. (25)

In short, the fast reactor was recognised as the ultimate system for a nuclear power programme well before 1952. By 1982 fast reactor R & D had become the principal function for the UKAEA which had lost the Production Group, AWRE and isotope production in the early 1970s. Technological and engineering difficulties aside, significant progress had been made. However, the date when a first British commercial fast reactor would enter service, first scheduled for the 1970s, was continually put back. This, arguably, is attributable to three factors. First, the conventional engineering difficulties encountered by the PFR highlighted the problems that a CFR would face. Moreover, the engineering problems facing the AGR programme did not inspire confidence. Second, the economics of CFR construction and operation were not conducive to a rapid introduction of fast reactors. Finally, and related to this, the availability and price of uranium was not as limited or as high as had been feared. In addition, the downturn in the ordering of thermal nuclear power stations world wide amid the economic crisis of the late 1970s confirmed the need to defer commitment to the CFR. The scarcity of uranium had been the original factor which prompted interest in fast reactor development in the UK. It is to this topic that we now turn.

4. RATIONALES FOR THE BRITISH FAST REACTOR PROGRAMME

As noted above the fast reactor was considered to be the most logical choice for a civil nuclear power programme as early as 1946. The reason for this was to become the fundamental justification for continued fast reactor R & D. Gowing identifies two key factors in the 1940s which
The prospect of a reactor that would utilise fuel efficiently and also produce additional plutonium was extremely attractive at a time when proved uranium resources were small. The whole of the United Kingdom's electric power consumption might be supplied from 80 tons of uranium a year. Indeed without fast breeders an industrial programme might be impossible. Herein lay the economic promise of fast reactors ... in the long term calculations of fast reactor's financial advantages compared with those of thermal reactors would depend in part on the scarcity and price of natural uranium and of the pure fissile materials, plutonium and uranium 235.(26)

Against the background of Harwell's deliberations in the 1940s two factors amplified the attractions of the fast reactor. A shortage of readily available and economic uranium coupled with an acute fuel crisis exposed the potential vulnerability of an industrial society.(27) The fast reactor might be the solution to these two problems. It would enhance energy security by cutting down the need for uranium imports and reduce dependence on coal for electricity generation. In the 1940s, and well into the 1950s, there was an acute shortage of high quality coal. The reactor's potential contribution to energy security proved to be the recurring theme in subsequent policy statements on fast reactor R & D. Even the subsequent setbacks to the programme have not diminished the reactor's attractions. Energy security is the key.

When work on the reactor was authorised in the 1950s it was precisely because "energy policy studies .... identified it as the alternative energy source most capable of contributing to our medium and longer-term energy needs by eliminating longer term fuel supply problems and maintaining stable prices for electricity generation."(28)
Again it is important to place this in its historical context. Coal production was still a major problem in the 1950s both in terms of quality and quantity.\(^{29}\) It is, therefore, not surprising that the fast reactor should have appeared so attractive. Moreover, as J.W. Dunworth of the UKAEA noted at the First UN Conference on the Peaceful Uses of Atomic Energy in 1955, "the fundamental reason for developing the fast reactor for the generation of industrial power was that it seemed capable of much more efficient utilization of uranium fuel than on a system based on thermal fission."\(^{30}\)

Whilst fast reactor R & D at Dounreay commenced in the 1950s, the first nuclear power programme based on thermal reactors was announced in 1955. These reactors were also fundamental to the future of fast reactor development. It was intended that the first generation thermal reactors would provide the plutonium fuel for future fast reactors. Franklin and Kehoe, for instance, wrote in September 1966 that: "For well over a decade the proper long-term use of plutonium has been seen to be in fast reactors. It was with this aim that the fast reactor experiment at Dounreay was authorised in 1953."\(^{31}\) Indeed the UKAEA itself stated in its Annual Report in 1967 that:

> Through its substantial investment in thermal reactor power stations, the UK will be building up the stocks of plutonium needed to fuel the fast breeder reactors with which the long term future of nuclear power will lie.\(^{32}\)

At the Fourth International Conference on Peaceful Uses of Atomic Energy held in Geneva in 1971, the relationship between British thermal reactor policy, and the rationales for fast reactor R & D was made clear. H. Cartwright of the UKAEA Reactor Group, R. Campbell of TNPG and P. Wolff of BNDC wrote that:
From the early 1950s, a substantial part of the UK's resources deployed on the reactor development programme has had as its objective the eventual construction on a commercial scale of sodium cooled FBRs. The construction and operation of such stations is an integral part of a total nuclear strategy for the efficient utilisation of uranium using both thermal and fast breeder reactors. The former provides the plutonium for the first changes of the early fast reactor stations. (33)

Therefore the objective of greater energy security was to be achieved by a thermal reactor power programme which would lay the foundation for the ultimate stage based on fast reactors.

Initially shortage of uranium resources had been one of the principal reasons which served to justify the fast reactor programme. By the mid 1970s this argument altered, but only in appearance rather than substance. Given both the projected expansion of civil nuclear programmes worldwide and forecasts of limited uranium availability, the justification for the fast reactor was, for the UKAEA, self-evident. In 1974 the UKAEA proclaimed that:

The increasing demand on uranium resources from expanding nuclear power programmes throughout the world confirms the Authority's policy of developing fast reactors with their high uranium utilisation as the future means of exploiting nuclear power. (34)

The prospect of energy independence, however, was still as attractive as it was in the 1950s. For the UKAEA:

Early demonstration of a full scale fast reactor will be essential if commercial ordering is to be possible from the mid 1980s to minimise imports of natural uranium, which will become increasingly
expensive as a result of the worldwide increase in the use of nuclear power. (35)

These views were not only entertained by the UKAEA which had an institutional interest in the continuance of the fast reactor. As its paymaster, Governments, irrespective of colour, have shared the UKAEA's enthusiasm for the fast reactor for ready strategic reasons. In June 1975, for example, an Energy Minister, stated:

We have to import uranium in order to sustain the industry. This is why the fast breeder reactor at Dounreay is significant for Britain, in the sense that we are world leaders in such technology. This is related to ensuring that in the long term we shall have a sufficiency of uranium to sustain our nuclear power programme. (36)

At the close of the period under review, 1982, the Conservative Government reiterated its support for fast reactor R & D. In a major policy statement in November 1982 the relevance for both UK and world energy supplies was confirmed. Despite the failure of the earlier dire forecast of limited uranium availability to materialise, and the world-wide decline in the expansion of thermal programmes, the need for continued fast reactor R & D was unquestioned by the UKAEA. (37) Furthermore, the ever increasing costs of continued support for the fast reactor was one pressing reason to reduce the scale of investment given the reduced urgency for a CFR. This acted as a stimulus for greater international co-operation. (38) Sir Peter Hirsh part-time Authority Chairman between October 1982 and September 1984 argued in 1983 that:

The goal of commercial introduction remains as important to long term energy security in the United Kingdom as it has ever been, although the time scale for probable commercialization has, on economic grounds, now moved to the early part of the next
century. (39)

Given the level of institutional and financial investment in fast reactor R & D it would be very difficult for the UKAEA to call into question the reason for its own existence. Moreover, enhanced energy security was a prospect that no government was prepared to abandon. The combination of these two factors ensured that fast reactor R & D would continue. Even the ready availability of coal, oil and gas supplies in Britain did not detract from the security arguments advanced for the reactor. In 1977 representatives of the three major nuclear organisations in Britain, the UKAEA, the BNFL and the NPC maintained that:

Notwithstanding the size of the UK fossil fuel reserves, sooner or later, the UK will cease to be able to meet its energy needs from indigenous sources. This situation could arise in the 1990s and a continuing and expanding thermal reactor programme is seen as an essential concomitant of future electricity programmes. Limitations on the extent of exploitable uranium resources point to the need for the development of new reactor systems and in particular the fast breeder. (40)

In addition to the presumed future pressures on uranium availability, world-wide competition for fossil fuels also served as a justification for fast reactor R & D. R.V. Moore, the Managing Director of the UKAEA Reactor Group, considered that world events in the late 1970s, the sharp rise in costs of coal and oil, the realisation that known resources, particularly of oil, in relation to ever increasing demand, are limited - re-emphasised the importance the UKAEA had always assigned to the successful development of a fast breeder reactor. (41) Rather than diminish the fast reactor's attractions, the economic crisis only served to confirm its inherent advantages.
There are three reasons for the resilience of the energy security arguments for the fast reactor. First, institutional momentum within the UKAEA ensured a powerful base. As the reactor had, by the 1970s become the last major function retained by the UKAEA, there was considerable bureaucratic interest in preserving and expanding the programme. Second, the various government departments which have had responsibility for atomic energy since 1952 have, in broad terms, shared the objectives of the UKAEA. Although the prestige of the UKAEA was not as great as it had been in the late 1950s and early 1960s, the UKAEA was nonetheless responsible for virtually all basic nuclear R & D in the UK. Moreover, even though the Department of Energy has been less enthusiastic about the fast reactor, the public line of the ultimate desirability of the reactor has remained unchanged.\(^{(42)}\) This is largely because the UKAEA is the only source of independent expertise from which the DEN can draw. Finally, and most importantly, the potential advantages of the reactor have remained attractive objectives for successive governments irrespective of cost or other factors which appear to detract from the reactor's potential. Energy security has always been the underlying attraction of nuclear power in general and the fast reactor in particular.\(^{(43)}\) The uncertainties of energy supply in the 1940s and 1950s provided the background against which the fast reactor programme evolved. Successive Middle East crises, 1956 and 1973 in particular, doubts over availability of economic sources of uranium; and pressures on fossil fuels, if not in the short term, then certainly in the long term, have combined to confirm the inherent logic of fast reactor research. In an international system comprised of sovereign states the strategic benefits of enhanced energy security are always likely to be attractive to governments. In the British context there is a relationship between fast reactor policy and non-proliferation strategy. The energy security benefits of the fast reactor came to form a part of British non-proliferation strategy in the late 1970s.
Rather than being a major threat to non-proliferation, the reactor becomes instead a positive advantage for non-proliferation objectives.

5. ENERGY SECURITY AND NON-PROLIFERATION OBJECTIVES

Fundamentally the UK subscribed to the view that rather than contributing to the risk of nuclear weapon proliferation, fast reactor construction should be encouraged for non-proliferation purposes. The clearest exposition of this view was given by the then Deputy Chairman of the UKAEA Dr Walter Marshall in April 1980 shortly after INFCE had published its report.\(^{44}\) Although given as the personal views of the Deputy Chairman, the arguments contained in the article nevertheless represent a definitive statement of British thinking on the question. Moreover, other public statements by Ministers, UKAEA and DEN officials in the late 1970s and early 1980s tend to confirm this. For example, the extent to which Ministers are dependent upon their UKAEA advisers, and therefore reflect the UKAEA corporate view, can be seen from a Prime Ministerial statement in 1979. On a visit to start up the first active run of the newly refurbished fast reactor fuel reprocessing plant, Margaret Thatcher remarked in relation to plutonium, "the worst thing you could do is to leave it lying around. The best thing to do is to burn it. The fast reactor is made to burn it."\(^{45}\)

The extent to which this reflects Marshall's view will become apparent below. The essential characteristic of the argument appears to be that a line of development, which the UK had every intention of continuing, is translated into a component of a desirable international non-proliferation strategy. A system which satisfies everyone's legitimate energy security interests is in the best interest of non-proliferation. This can be seen from a detailed examination of Marshall's argument as outlined
in the Atom, article.

The lecture, originally delivered to the Royal Institution has three key sections. These are: Economic value of plutonium; non-proliferation implications; and philosophical reflections. The sequence is important. Crucially, non-proliferation objectives should be met by the logical development of nuclear fuel cycles worldwide. In short, non-proliferation objectives are best fulfilled from the strategic and industrial applications of nuclear power. There is no question of a non-proliferation regime being foisted onto a reluctant nuclear industry. Instead the evolution of both systems is mutually reinforcing rather than intrinsically irreconcilable. As with the domestic British programme the arguments which stress the advantages for energy security and resource economy of fast reactor development now reappear in the context of non-proliferation policy. In short, there is a clear relationship between internal British policy and British non-proliferation strategy. As with British nuclear export policy, domestic objectives became identified with a practical non-proliferation strategy.

Marshall identifies the essential prerequisite for non-proliferation in the introduction to the Lecture which he repeats in the opening paragraph of the section Economic value of Plutonium:

no lasting non-proliferation regime can be based upon a policy of denial and it was important that any stable (or slowly evolving) regime be constructed so that the economic self-interest of all countries was not infringed.(46)

Marshall continues, "that no technical or economic solution can ever serve as more than a partial answer to what is fundamentally a political problem". (47) This is the
bottomline of all British statements on the proliferation question and is in no small measure a view confirmed by the British experience. As noted in Chapter 2 it was Attlee who had made this fundamental observation as early as November 1945.

Central to Marshall's argument is the position of plutonium in the nuclear fuel cycle. Marshall identifies five possible alternatives for plutonium use: the once-through cycle (spent reactor fuel is stored indefinitely in cooling ponds); the reprocessing cycle; thermal recycle; the fast reactor launch cycle; and the fast reactor established cycle. However, the potential self-sufficiency of the fast reactor and pressing need to conserve uranium point logically to the latter two fuel cycles. The once-through cycle is, in addition to being a wasteful use of uranium, produces more and more plutonium which although stored becomes more accessible as the radioactivity of the spent fuel in which it is contained declines. (48) As uranium becomes scarcer and more expensive, logic would suggest the fast reactor as the most economic choice for nuclear electricity generation in the advanced industrialised states.

Given the need for an initial stockpile of plutonium to launch a fast reactor programme, availability becomes a problem. Marshall, however, sees a practical solution to this problem. There would be an economic incentive for a state embarking on a fast reactor programme to acquire spent fuel from a state which operates only thermal reactors. Both states would benefit economically. Moreover, such a trade based on purely economic and energy security grounds furthers the cause of non-proliferation. It is worth reproducing Marshall's view at length:

This mutual benefit, which is a natural consequence of international trade in spent thermal fuel, also assists an international non-proliferation regime
because it concentrates, on a voluntary basis, the use of plutonium and fast reactors in a limited number of countries. But the advantages of this international trade are more profound than that because a trade in spent fuel does not merely produce an economy benefit to both participants in the trade; we shall show later that a fair and equitable economic trade produces equal economic benefits to the participants. In this case we have produced the remarkable conclusion that fast reactors can benefit equally those countries that have them and those that do not! We have therefore produced an incentive for those countries which have fast reactors to build more and those which do not have fast reactors to avoid their use altogether. This assists our non-proliferation objectives still further because if such a regime could be set-up and maintained the majority of countries in the world, would be those with small programmes, would in their own self-interest avoid the use of fast reactors.\(^9\)

In short, it is best that the plutonium produced should be incinerated in the fast reactor and kept in a form unsuitable for weapons purposes and confined to as few states as possible. Moreover, the plutonium is safeguarded since it is less accessible than if it were contained in spent reactor fuel. The energy security interests of all states are satisfied since assurance of economic and stable supply is guaranteed. Thus the incentive to pursue independent nuclear programmes is greatly diminished, theoretically. Marshall is, in effect, proposing to make a virtue out of a predetermined policy. The UKAEA would continue with its fast reactor R & D without this additional reason to pursue it. Furthermore, this fuel cycle is also linked to the development of thermal reactor power programmes. It is important that reprocessing services should be made available for states without their own facilities. A state with a small nuclear programme
cannot justify the cost of a commercial reprocessing plant. From the economic and non-proliferation perspective it is preferable for such fuel to be reprocessed by those states with fast reactor programmes. Moreover, it is better to keep the locations of separated plutonium to a minimum. It is no coincidence that provision of reprocessing services forms a substantial part of BNFL's overseas business. However, this strategy would fail if, "those countries operating fast reactors do not give fair value for the spent fuel they require. And they fail in the absence of a sufficiently secure uranium market offering adequate guarantees of security of supply to the thermal reactor countries."(50)

The basis for this strategy can be directly traced to two interrelated factors. First, the rationales and objectives of the British civil nuclear programme; and, secondly the conditions and external political factors which shaped both the British perspective and nuclear programme in the 1940s and 1950s. As noted in Chapter 2 doubts about availability of uranium ore and the ability of existing energy sources to meet projected demand were seminal factors in the formulation of British nuclear policy. It is axiomatic that energy is fundamental for an industrialised or industrialising state. The British concern in the 1940s and 1950s was that energy shortages would inhibit economic recovery and growth. This realisation appears to have shaped Marshall's outlook:

The developing countries of the world hope to improve the lot of their people through industrialisation and improved agricultural practice. Both require energy. The advanced countries of the world are already close to exhausting mankind's oil reserves before the majority of mankind, in the developing countries, can afford to use them ... The advanced countries are now heading towards exhaustion of mankind's accessible uranium reserves before the
developing countries have a chance to use them either. The long term future lies with fast reactors, and our objectives must be to get them operating before the remaining uranium becomes too expensive. (51)

When compared with the discussion in section three this statement is strikingly familiar. However, the fast reactor's long-standing attraction was the alluring prospect of energy self-sufficiency and independence. Marshall appears to be calling for a much greater degree of interdependence rather than independence. But in effect the basic argument is not "to any serious extent" undermined. (52) Marshall, instead advocates that a state introducing fast reactors should plan to reduce somewhat its dependence on uranium imports, and to introduce a corresponding dependence on spent fuel imports, so as to be able to launch a few more fast reactors in the place of thermal reactors. (53) There has only been, as noted above, a shift in emphasis rather than a fundamental departure from established policy. Moreover, this shift is largely motivated by the need to accommodate both non-proliferation objectives and greater energy security within the same basic policy. This outlook is borne out of the recognition that policies based on denial are counterproductive. Since nuclear power already exists and substantial quantities of plutonium have already been produced, it is not a question of abandoning civil nuclear power; rather it is a question of identifying the best method for managing the existing situation. In 1978 Marshall argued that, "the introduction of fast reactors limits the world inventory of 'extractable' plutonium. From a non-proliferation point of view both these steps are highly desirable." (54)

In short, as Sir John Hill had noted in 1976, nuclear weapons proliferation would not be influenced in any way by banning the fast reactor. (55) On the contrary, fast
reactor development should be encouraged precisely because it would keep weapons grade plutonium locked away in the reactor core. In one sense Marshall's conclusions appear to contradict one of INFCE's central conclusions that no one fuel cycle was any less proliferation resistant than any other. However Marshall's basic argument is that a sensible non-proliferation strategy should make use of those fuel cycles which are most likely to be adopted. This involves integrating fast reactor and thermal reactor programmes worldwide. The central factor here, however, is the relationship between the UK programme and a non-proliferation strategy based on fast reactors. As noted above Marshall's views are by no means singular. They are representative of a wider British outlook. Two years before Marshall's lecture, Sir John Hill, who was then both UKAEA and BNFL chairman, had made plain the relationship between the rationales for the British nuclear programme and British attitudes to non-proliferation:

For every million tons of oil that is replaced by nuclear power there is a million tons of oil left in the ground to be used by lesser developed countries. The wealthy industrialised countries have built up their economies on the basis of cheap energy, coal, and more recently, oil and gas. In many ways there is much to be said for the highly industrialised countries with a huge energy consumption of nuclear, and leaving some relatively modestly priced oil and gas to the developing countries to use to develop their economies in the way we did in the last 50 years. From that point of view, I believe that, if the world were run on logic (which it is not), the fast reactor would best make its contribution in the big industrialised countries. These would then be the only countries which need reprocessing plants.\(^{56}\)
6. CONCLUSION

It does, however, need to be pointed out that the non-proliferation benefits of fast reactors as outlined by Marshall and Hill are not the principal reasons for the R & D programme at Dounreay. The need to enhance energy security in the 1940s and 1950s preceded any need to consider the proliferation implications of fast reactor technology. However, the emphasis was placed on security of supply, in this case uranium and plutonium fuel at economic prices, is not restricted to the fast reactor. Security of supply plays a major part in other areas of British thinking on non-proliferation. For example, the fast reactor strategy outlined above is also linked to not only the IAEA safeguards system, but to other institutional arrangements of the 1970s and early 1980s such as International Plutonium Storage and Regional Fuel Cycle Centres. Both these proposals were actively supported by the British within the IAEA. The central point to note, moreover, is that the British perspective is not only shaped by British experiences, but it also corresponds to British domestic objectives. Fast nuclear research was initiated, and continued, in Britain because of its potential contribution to energy security. The problems associated with dependence on uncertain uranium supplies, production problems of the coal industry and future availability of fossil fuels in general have been the basis of all arguments in favour of the fast reactor. This attitude, in turn, has been a decisive factor in British thinking on the relationship between the fast reactor and nuclear proliferation. As with export policy, domestic imperatives have shaped the position on fast reactors and the proliferation question.
PART 2

CHAPTER 8

BRITAIN AND THE NON-PROLIFERATION TREATY 1965-1968

1. INTRODUCTION: NON-PROLIFERATION POLICY 1945-1968

Between 1952 and the early 1960s the international perception of the threat posed by the further proliferation of nuclear weapons changed. This was instrumental in bringing about the NPT. The fundamental premise shared by a majority of the states was that the impending emergence of additional nuclear weapons states (NWS) would undermine and threaten international security and stability. Before 1968 US non-proliferation policy went through two distinct stages. From 1946 to 1953 the Atomic Energy Act sought to impose a tight control on the dissemination of knowledge and technology. This strategy failed. Eisenhower's Atoms for Peace speech at the UN in 1953 initiated an about-turn in US policy, and as noted in chapter 4 the British not only supported and encouraged this transition, but took a leading role in fleshing out the details. Instead of a policy of denial, the US Government made nuclear information and hardware available to states embarking on research and development programmes. As monopoly supplier of LEU and HEU for US supplied research reactors, successive US Governments were able to monitor the nuclear programmes of non-nuclear weapon states (NNWS) through bilateral relationships of dependence. Atoms for Peace was born out of the recognition of the failure of technology denial as the Russian and British nuclear tests demonstrated. The Eisenhower Administration tried to prevent further weapons proliferation and exclude or minimise Russian influence in Western Europe and the developing world.

The creation of the International Atomic Energy Agency in 1957 was central to the Atoms for Peace Programme. Its
principal functions were to promote the peaceful uses of atomic energy and ensure that ostensibly civil facilities and materials were not used for military purposes. Atoms for Peace was endorsed by the British.\(^1\) British attitudes to non-proliferation were shaped by four factors. First, Britain's treatment at the hands of the Americans between 1946 and 1953 suggested that policies based on technology denial were counter-productive. Second, one of the principal contributions for the 1955 nuclear programme was the perceived benefits of atomic energy could make to energy security. Therefore if nuclear power could contribute to British energy security and industrial development, then it could do so for other states. Third, pursuit of nuclear exports, reactors and fuels especially, was one of the major objectives of the domestic programme. Consequently, any international non-proliferation regime should not constrain or prevent British nuclear exports. Finally, as noted in Chapter 3, vertical proliferation was not considered to be the principal cause of horizontal proliferation. There was thus no contradiction between the objectives of a non-proliferation agreement and the British nuclear weapons programme in general, and the 1958 US-UK Mutual Defence Agreement and the 1963 Polaris Sales Agreement in particular.

2. THE ORIGINS OF THE NON-PROLIFERATION TREATY

Until the late 1950s nuclear proliferation had not been considered separately from the elimination of nuclear weapons in general.\(^2\) International non-proliferation policy was largely shaped by the US. In other words proliferation was divorced from superpower disarmament and could therefore be considered separately from, and not dependent upon progress on General and Complete Disarmament. This reflected a move away from pursuit of the all-embracing disarmament programmes to the more particular arms control process in which the object was to stabilise the strategic balance. This facilitated specific measures such as the Antarctic Treaty and the Partial Test
In 1958 Ireland tabled its first non-proliferation resolution at the United Nations General Assembly. However, it was not until 1961 that the UNGA unanimously adopted a resolution calling on all states to conclude an international agreement in which they would agree not to transfer or acquire nuclear weapons. The 1961 resolution reflected the widespread view that the further spread of nuclear weapons posed a threat to world security. Once the PTBT was opened for signature on 5 August 1963 the way was cleared for a specifically non-proliferation treaty. Negotiations took place at the Eighteen Nation Disarmament Committee in Geneva between 1965 and 1968. Indeed 1965 saw the first appearance of the term non-proliferation. A resolution adopted by the UNGA in its 20th session in 1963 called for the negotiation of a non-proliferation treaty on the basis of the following five principles: (i) the Treaty should be devoid of any loopholes which might permit nuclear or non-nuclear powers to proliferate, directly or indirectly, nuclear weapons in any form; (ii) the Treaty should embody an acceptable balance of mutual responsibilities and obligations of the nuclear and non-nuclear powers; (iii) the Treaty should be a step towards the achievement of general and complete disarmament and, more particularly, nuclear disarmament; (iv) there should be acceptable and workable provisions to ensure the effectiveness of the Treaty; (v) nothing in the treaty should adversely affect the right of any group of states to conclude regional treaties in order to ensure the total absence of nuclear weapons in their territories.

The principal architects of the NPT were the co-chairmen of the ENDC, the Soviet Union and the United States. The first drafts of a NPT were presented by the co-chairmen, but were unacceptable to the neutral and non-aligned states. They were wary of provisions which appeared to place all the obligations and sacrifices on them. Early in
the negotiations it became clear that there were four separate contentious issues, three of which became incorporated as Articles in the final treaty. Safeguards, access to the benefits of peaceful nuclear energy, prevention of further vertical proliferation, security assurances to NNWS were, and remain central to the non-proliferation regime. Articles III and IV which cover safeguards and peaceful uses are of particular relevance to the British position on non-proliferation. The security assurance question was resolved outside the framework of the NPT and will not be discussed here. Instead the three NWS in the Eighteen Nation Disarmament Committee (ENDC) offered assurances to the NNWS at the United Nations General Assembly (UNGA).

By the end of 1966 no substantial progress had been made and it took a further fifteen months before a final text was produced acceptable to a majority of the ENDC. In May 1968 an UNGA Resolution sponsored by twenty states, including Britain, endorsed the NPT and asked the depositary states, Britain, USA and USSR, to open the treaty for signature as soon as possible. On 12 June the UN approved the NPT by 95 votes to 4 with 21 abstentions. The Treaty was opened for signature on 1st July.

3. THE BRITISH ROLE IN THE NEGOTIATIONS 1965 - 1968

Although the United States and Soviet Union played a predominant role in the negotiations, the British made an important contribution. Indeed the first text submitted to the ENDC in the summer of 1965 "owed much to British thinking" even though it was tabled by the US. Moreover, the British had circulated this text at the North Atlantic Council in July 1965. Despite this it is difficult to establish the extent of the British contribution to the final text, and how significant it proved to be. There are no publicly available documents
which reveal the thinking and objectives behind British policy. Until Foreign Office, Commonwealth Office, Ministry of Defence, Ministry of Technology and Cabinet Office files are opened to the public it is necessary to rely on an examination of the statements made by British delegates at the Plenary Sessions of the ENDC and the UNGA First Committee.\(^{(15)}\) From these statements it is possible to build up a picture of the British position.

The NPT has been regarded as a product of superpower conspiracy; a view not shared enthusiastically by London. George Quester has observed that in Britain, "there was obviously some embarrassment at the extent to which the US and the Soviet Union had together privately composed the treaty, consulting Great Britain no more than any one else."\(^{(16)}\) Whether the British were consulted or not is not the principal object of this inquiry. It is more important for the purpose of this study to establish the British position on certain of the key issues at the ENDC. It is, however, unlikely that possession of nuclear weapons made the British contribution to the proceedings any more substantial or crucial.\(^{(17)}\)

At the level of appearance it seems that the British attached considerable political importance to the objectives of non-proliferation. During the PTB negotiations the Prime Minister Harold MacMillan had already considered arms control's next objective. In a letter to President Kennedy in March 1963, MacMillan noted that:

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I have a feeling that if we get the test ban agreement, there would be another prize just as important to be secured. We ought to be able simultaneously to get a non-dissemination agreement: an undertaking that is, from the non-nuclear countries not to accept nuclear power at the gift of others, for their sole use, and from nuclear powers
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not to give nuclear weapons or knowledge to non-nuclear countries.\(^{(18)}\)

The 1965 Statement on Defence Estimates observed that:

The Chinese explosion must remind us that the stability so far achieved in relations between Soviet and Western Alliances might rapidly be jeopardized by the spread of nuclear weapons to countries which do not now possess them. For this reason international agreements to prevent the dissemination or acquisition of nuclear weapons must be an urgent aim of our foreign policy.\(^{(19)}\)

Three years later when the NPT was opened for signature the Prime Minister, Harold Wilson, described the NPT "as the most important measure of arms control and disarmament or which agreement has yet been reached."\(^{(20)}\)

4. **THE MULTILATERAL NUCLEAR FORCE AND THE ATLANTIC NUCLEAR FORCE**

Perhaps the most important obstacle to overcome before a non-proliferation treaty could be translated into reality was the interrelated problem of the MLF/ANF and nuclear-sharing arrangements within NATO. US proposals for a MLF were designed to reduce the likelihood that West Europeans, the FRG in particular, would produce their own weapons. This, however, alarmed the Russian Government. Any move which seemed to bring the West Germans a step nearer the "nuclear trigger" was an anathema to the Russian leadership. Related to this was the Anglo-American nuclear relationship in the aftermath at the Nassau Agreement. The original US proposal, initiated by George Ball, envisaged surface ships with mixed nationality crews which would be armed with Polaris missiles. An ulterior motive was to bring the British Polaris force under tighter control which was apparently required by the provisions of the Nassau
Agreement.(21) But the principal objective of the MLF was non-proliferation. It would reduce the incentive non-nuclear NATO states might have, especially the FRG, for acquiring an indigenous nuclear weapons capability, by providing greater co-operation in nuclear matters. Within the US Administration there was a considerable body of opinion against "independent deterrents for Europe." MLF was a device to arrest Franco-German nuclear co-operation.(22) For the Russians, however, any move which appeared to bring West Germany closer to nuclear decision making had to be prevented. MLF was, for the Russians, a threat equal to proliferation itself.(23) Consequently no progress towards a non-proliferation treaty could be made until the MLF/ANF problem was resolved.

By and large the British were ill-disposed towards the MLF. Indeed Harold Wilson described MLF as "a grave step in the proliferation of nuclear weapons."(24) The British feared that the MLF would undermine the position of the "independent deterrent". The Ministry of Defence was emphatically opposed since it considered mixed nationality crews as unworkable. However, there were public and endemic differences of opinion between the MOD and the Foreign Office. The FO took the view that the UK could not afford to stand aside from an important development in the relations between the US and FRG.(25) In contrast to the US initiative the British proposed an Atlantic Nuclear Force(26); however, it was never intended as a serious alternative, but rather a means to undermine the MLF concept.(27) The Soviet Union continued its offensive against the MLF/ANF proposals, for them there was no difference.(28)

Sir John Cockcroft argued in July 1965 that ANF would not be, "disseminatory since decisions about the force would require the consent of a number of countries which in any case involve the participating nuclear powers and there would be no transfer of nuclear weapons technology to non-nuclear participants."(29) Lord Chalfont took a similar
view at the Eighth Session of the ENDC. For the British Government ANF did not involve dissemination and it was determined that ANF would never include any element of dissemination. Nor would the British Government ever consent to taking part in any nuclear sharing arrangement within the Western Alliance that entailed placing the control of nuclear weapons in the hands of any non-nuclear country, including the FRG. The Foreign Office was concerned that the MLF would damage relations with the Soviet Union and thus delay creation of a non-proliferation treaty. By the end of 1963 the MLF/ANF negotiations had made no substantial progress. The matter was eventually dropped largely to encourage East-West discussions on a non-proliferation treaty.

The key arrangement, or rather agreement to disagree, on nuclear sharing arrangements in NATO was concluded during Andrei Gromyko's visit to Washington in October 1966. But the British contributed to the failure of the MLF concept. Creation of the Nuclear Planning Group in 1967 went some way to solving the problem of nuclear consultation with the Alliance. The Soviet Union recognised that it could not use a NPT to prevent, or obstruct or hinder nuclear consultation or dual-key arrangements within NATO. This cleared the way for the conclusion of the treaty, although it was to take almost two more years.

5. BRITAIN AND THE NON-PROLIFERATION TREATY PROVISIONS: ARTICLES III, IV, VI

Although the first drafts of the NPT were largely drawn up by the superpowers, the British made important contributions. Other NNA states also proposed significant amendments. However, the British helped phrase the treaty language on the three most contentious areas: safeguards, Article III; access to peaceful nuclear technology, Article IV; and further arms control measures, Article VI. An
understanding of the British position on these issues is necessary for a clearer understanding of British non-proliferation policies in the 1970s. Discussion will focus exclusively on these three articles.

6. ARTICLE III

Article III contains safeguards provisions to ensure that peaceful activities are not used for military purposes. India, however had waged a long-standing campaign against safeguards within the IAEA. It regarded safeguards as an unwarranted intrusion on national sovereignty, and campaigned against them in the ENDC. For former colonial states and the neutral and non-aligned this was, and remains, a sensitive issue. Furthermore, intrusive inspection and verification procedures were viewed by industrialised states as a cloak for commercial espionage. This was of particular concern to the FRG and Japan even though neither were members of the ENDC. Willy Brandt, for example, the West German Foreign Minister stated that the FRG was not ready to accept anything at all which hindered the peaceful utilisation of nuclear energy. Sir Solly Zuckerman, Chief Scientific Advisor to Secretary of State for Defence 1960-1966 and to HMG 1964-1971, travelled to Bonn in the Spring 1967 to allay German anxieties about the non-proliferation treaty. In short, international inspection and control was one of the most difficult obligations for the NNWS to accept. The NNWS feared that safeguards would threaten successful commercial operation of nuclear power since intrusive inspection would hinder the operation of nuclear power stations. Moreover, the threat of commercial espionage was also significant since both the West Germans and Japanese hoped to export nuclear reactors.

During the drafting of the IAEA statute in the 1950s the extent of safeguards provisions was a contentious issue. Indeed it was largely through concern at
possible diversion of civil materials that the US and UK in particular tried to include in the IAEA statute safeguard clauses designed to keep a check on materials supplied.\(^{43}\)

However, from 1957 until 1964 little was done to activate the IAEA's safeguards system. The NPT led to the major extension of the IAEA safeguard system when the Treaty entered into force in 1970.\(^{44}\) During the negotiations the safeguards provisions took time to hammer out. It was here that the British delegation was able to make a special contribution.

Sir Solly Zuckerman stated that safeguards:

> offers the most promising way of instituting active constraints to the manufacture of nuclear weapons, and so of implementing a non-proliferation treaty. It facilitates a positive rather than a negative approach to the development and control of nuclear energy: it does not stifle its civil applications.\(^{45}\)

This assumption formed the basis of the British approach to the safeguards issue in the ENDC.

On 24 August, 1967 the US and Soviet Union submitted separate but identical draft texts to the ENDC. However, the contentious safeguards Article III was left blank.\(^{46}\) In order to overcome the fears of the NNWS that safeguards would hamper the commercial operation of nuclear power stations, or provide a cover for industrial espionage, both the US and UK declared that they would accept such international safeguards as the Treaty might specify in their territories.\(^{47}\) This commitment was made with an "escape clause". Safeguards on British civil nuclear facilities would be "subject to the exclusions of national security". The military reactors at Calder Hall and Chapelcross and the Windscale reprocessing plant in
particular were excluded; moreover, the British government reserved the right to use plutonium produced in civil reactors for military purposes. But this was not the objective of the safeguards offer; instead, it would demonstrate that "a safeguards system would not impose industrial or economic burdens on treaty signatories."(48)

Fred Mulley noted that since the British and Americans were the most advanced civil nuclear powers they would be the most vulnerable to commercial espionage, yet had voluntarily submitted their civil sectors to safeguards though not required to do so by the Treaty.(49) This decision to open the civil sector to safeguards has been described as a "willingness to endure, and be seen to endure, what one senior IAEA official has termed an equality of misery."(50)

Minister of State for Foreign Affairs, Fred Mulley, informed the House of Commons that:

a key issue in the negotiations at present taking place in Geneva to secure a non-proliferation treaty has been the safeguards to be applied to ensure that there is no diversion by the non nuclear weapon signatories of the Treaty of materials from their civil nuclear programmes to nuclear weapon purposes.

To assist these negotiations, Her Majesty's Government have decided that at such time as international safeguards are put into effect in the NNWS in implementation of the provisions of a treaty they will be prepared to offer an opportunity for the application of similar safeguards in the United Kingdom subject to exclusions for national security only.(51)

It should be pointed out that the relevant agreement did not enter into force in the UK until 1978.(52) Before the December 1967 offer one CEGB Magnox station had already
been subject to IAEA inspection. At the time Bradwell was the largest power station opened to the IAEA when the first inspection took place in October, 1967.\(^{(53)}\) The UKAEA observed that:

The UK believes that the acceptance of international safeguards thus constitutes a valuable step along the path to non-proliferation, and therefore hopes that other countries will follow her example (re Bradwell).\(^{(54)}\)

The Bradwell inspection, along with similar inspections in the US, were intended to be a practical demonstration of the workability of the system and that IAEA safeguards did not hinder economic operation of power reactors.\(^{(55)}\) Moreover, these inspections provided the IAEA with valuable first hand experience of safeguarding large nuclear plants.

In January 1968 a draft treaty containing safeguards article was tabled at the ENDC. The Article III compromise lay in a phrase suggested by the British that safeguards agreements would be set forth in a separate agreement with the IAEA, rather than acceptance of IAEA safeguards as such.\(^{(56)}\) In short, each NPT signatory would negotiate a separate agreement with the IAEA taking into consideration that signatory's own nuclear installations.

The British Government was perfectly aware of the dangers of enforcing safeguards on reluctant states. Once again the Anglo-American nuclear relationship proved crucial. LEU was required for the AGRs which had been selected for the Second Nuclear Power Programme.\(^{(57)}\) But the UKAEA's Capenhurst enrichment plant had a limited output. Given the high cost of electricity, there was little chance of increasing cheap supplies of LEU indigenously. Supplies were sought instead from the US. However, a combination of factors, the US position as monopoly supplier, hardening attitudes in the US to supplying of materials under
safeguards, and fear of assisting a commercial reactor competitor led to American insistence that all material transferred to Britain would have to be under safeguards. As Bertrand Goldschmidt notes the British government was irritated by this largely because it considered safeguards on British installations and materials as nonsensical given British status as a NWS. Moreover, Britain was already receiving oralloy for the Polaris A-3 warheads. The potential unreliability of the US as a LEU supplier, manifested here by insistence on unreasonable conditions, was one of the reasons for the formation of URENCO. URENCO hoped to provide an independent European source of LEU. It is thus conceivable that the British Government recognised the dangers accompanying unilateral imposition of seemingly unreasonable provisions. Rather than contribute to non-proliferation objectives, such policies would have the opposite effect.

Whilst the NPT negotiations continued, the British applied to join the EEC. However, there was a potential source of conflict between the objectives of British non-proliferation policy and membership of the EEC. EURATOM (European Atomic Energy Community) already had its own safeguard system and its member states feared that the IAEA would replace it. As Arnold Kramish noted in June 1967 British application to join the EEC presented them with a unique dilemma in the ENDC. Support for one might alienate the other and thus compromise the British position on both. When Mulley announced that safeguards would apply to the UK he did not specifically mention the IAEA. As Shaker notes this might have been intentional so as not to antagonise EURATOM. In March 1967 Foreign Office Minister Lord Chalfont noted that a NPT treaty:

would have to take account of regional considerations. In Europe a high degree of civil nuclear collaboration had been developed and was
subject to rigid controls operated between equal and sovereign states. Members of the Euratom Community, had a legitimate concern that the treaty should not damage this delicate mechanism and no such damage was necessary. The safeguards provisions must be fitted into a universal framework.\(^{(63)}\)

Later that year Fred Mulley was more specific:

HMG's support for the treaty was in no way weakened by our application to join the European Communities. It was natural that we should look at the effect of the treaty on our European neighbours and for them to try to ensure that the new agreement should not damage their own organisation, Euratom. The non-proliferation treaty must take account, like any other international treaty, of existing agreements and obligations.\(^{(64)}\)

There were, in the British view, no inconsistencies between support for EURATOM and the IAEA. Indeed when the UK joined the EEC in January, 1973 all civil plants were subject to EURATOM safeguards. Subsequently, both European and IAEA safeguards were applied to UK civil plants with no apparent conflict.\(^{(65)}\)

7. ARTICLE IV

The first US and Russian draft treaties contained no "Article IV". This omission was particularly galling to the LDCs. They feared that such a treaty would prevent any exchange of information or technology for peaceful purposes.\(^{(66)}\) Consequently, neutral and non-aligned ENDC members proposed amendments to secure greater rights of access to the peaceful benefits of nuclear power; for example, Mexico, Brazil and Nigeria took the lead on this issue.\(^{(67)}\)
At the ENDC the British supported and promoted inclusion of what was to become Article IV of the Treaty. (68) There were two interrelated reasons for this. First, the British had a longstanding commitment to the objectives of the Atoms for Peace programme. (69) In January 1968 Mulley stated that:

We in the UK have for long advocated the fullest possible co-operation in the field of civil nuclear development. We were, it will be recalled, one of the founders of the IAEA whose main purpose is to promote such co-operation. (70)

Second, inclusion of such a provision would assuage NNA doubts that the NPT would be an unfair bargain which would keep them in an inferior position. In the 1970s this interpretation of the NPT as a bargain between the NWS and NNWS, especially lesser developed ones, assumed a greater significance in British nuclear thinking. It become a justification for BNFL's expansion of its overseas fuel cycle business. In return for forswearing nuclear weapons the NNWS would be entitled to share in the benefits of civil nuclear power, and have access to fuel cycle services in particular. But there was no question of providing technologies, materials and services for nothing. (71)

Between 1965 and 1968 the British ministerial representatives, Lord Chalfont and later Fred Mulley, took every opportunity to declare British commitment to the widespread availability of civil nuclear power. Lord Chalfont noted at an ENDC Plenary Session on 25 March 1967 that:

Many people have expressed the fear that even if everyone concerned in a non-proliferation treaty were influenced by the sincerest and best motives, the inhibition of a non-proliferation agreement would inevitably affect the spread of peaceful nuclear technology. As I have consistently said here - and I
say it again now - my Government would not support a treaty that interfered with the legitimate development of civil nuclear programmes.(72)

Fred Mulley made the same point in October:

The United Kingdom delegation has made the point repeatedly that we cannot support a treaty which impedes the civil development of nuclear energy. We believe in the absolute right and the absolute need for free and untramelled co-operation in this field.(73)

Commitment to the dissemination of the peaceful atom was a longstanding feature of British policy. As noted in chapters 4, 5 and 6 pursuit of nuclear exports had been an essential feature of British civil nuclear policy. Therefore the NPT should not, in the British view, restrain nuclear trade. Article IV did not mark a departure from existing policy in the way that the Atoms for Peace programme did for the US; on the contrary, Article IV reaffirmed British commitment to Atoms for Peace principal. Indeed the Foreign Office took the view that NNWS could only be persuaded to sign the treaty if availability or access to peaceful nuclear technology, information and services was secured.(74) The assumption here was that it would be nuclear scientists advising NNWS governments, and they would only recommend signature and ratification of a non-proliferation treaty provided it did not exclude them from the benefits of nuclear power. In fact Mulley stated that his government supported the insertion of Article IV because it was convinced that nuclear energy could bring possible benefit to the NNWS, particularly in the developing world.(75) Article IV's provisions are central to the British view on how best to prevent proliferation, if for no other reason than that the British had a commercial interest to protect.(76) Assurance of supply of nuclear fuel moreover would reduce the incentives for
states to build their own fuel cycle plants. Enrichment and reprocessing plants produce separated fissile material and are therefore sensitive from the proliferation point of view.

Once the ENDC approved the final draft treaty it was submitted to the UN General Assembly. At a meeting of the First Committee on 28th May Mulley made the clearest statement on British attitudes to Article IV, and its relationship to non-proliferation. It is worth reproducing at length:

Some states have expressed disappointment with the provisions of the treaty confirming the peaceful uses of nuclear energy and have in some cases suggested that the outcome of the treaty will have the effect of placing the NNW signatories in some sort of service to the NWS. This is a complete misconception of the purposes and effect of Articles IV and V and is in fact the reverse of the truth. The United Kingdom has long recognised the desire of developing countries to share in the benefits that nuclear energy can bring and fully support this desire. We supported the insertion of Article IV because we are convinced that it can bring positive benefits for NNW countries, particularly those in the developing world. Article IV lays a positive obligation on states to contribute either alone or in co-operation with other states in the international organisations to further the development of nuclear energy for peaceful purposes, especially in the territory of the NNW party to the treaty. The United Kingdom already does this both on a bilateral basis and by playing a full part in the IAEA and we shall continue to do so. We shall fully recognise our obligations under the treaty and I am confident that other states will do the same. Indeed the best guarantee that can be offered is the fact, for which many countries here
can testify, that the three nuclear powers which have expressed their intention to sign the Treaty already have an excellent record of co-operation with non-nuclear countries in this field. The treaty will encourage and intensify this co-operation (my emphasis) and therefore I cannot understand why it should be argued that the effect of the treaty will be to lead nuclear powers to adopt a more restrictive attitude to lesser developed states. I am further convinced that the effective working of the safeguards measures will increase the climate of confidence and further facilitate these exchanges. (78)

Three observations may be made on this definitive statement on British thinking on non-proliferation. First, the NPT, Article IV especially, demonstrates the continuity of British nuclear policy; second, all exchanges and transfers of materials and hardware will, eventually, be subject to a uniform worldwide safeguards system; and, third, and most importantly, the NPT represented a further institutionalisation of the non-proliferation regime. With the safeguard provisions and the political commitment to refrain from acquiring nuclear weapons, nuclear trade would become easier. A key assumption here is that if a state is determined to acquire nuclear weapons it will also do so as consequence of a political decision, not simply because it possesses the relevant nuclear hardware. (79) Once provision was made for Article IV, the Treaty became more acceptable to the NNA.

8. ARTICLE VI

Article VI on NWS arms control and disarmament was designed, in part, to redress the balance of the treaty by ensuring that not all the obligations fell on the NNWS. Articles I and II prohibited receipt and acquisition of nuclear weapons, by NNWS whereas Article VI looked to limit
the nuclear stockpiles of the existing weapon states.

India was most insistent on this issue; for instance, the Indian delegate in May 1967 maintained that the NPT could be purposeful only as part of a general concept of disarmament, and not as a simple imposition of non-armament on unarmed countries.\(^{(80)}\)

Although the British were convinced of the urgent need for a non-proliferation treaty, they were not prepared to make such a treaty dependent on the conclusion of simultaneous or prior progress in nuclear arms control. But it was recognised that the ultimate success of the NPT was dependent on the successful conclusion of arms control agreements. NNWS took the view that this would require reductions in super-power arsenals and a comprehensive test ban. These were regarded as a litmus test of superpower sincerity.

Once the problem of control of nuclear weapons within alliances was resolved, Lord Chalfont noted that a non-proliferation treaty, "would not make sense unless it were followed by measures of arms control and disarmament."\(^{(81)}\)

Fred Mulley rejected the proposition that arms control agreements should be concluded first as a pre-condition of a NPT. It was unlikely that, "the great nuclear powers could be forced to reach quick agreement on measures of disarmament, whereas the need for a treaty was becoming more urgent."\(^{(82)}\) This point was repeated at subsequent sessions of the ENDC and UNGA First Committee. Indeed Mulley argued that prior arms control agreements should not be a condition for a non-proliferation treaty lest the "best be made the enemy of the good."\(^{(83)}\) Once the NPT was opened for signature on 1st July, 1968 the ENDC reconvened to consider further arms control measures. At the first session Mulley observed that "many countries made their support for the Treaty conditional on being followed by meaningful negotiations... We must expect that the rate of
ratifications for the Treaty may well be influenced by the rate of our work here.\(^{(84)}\) It thus appeared as if the British were committed to further nuclear arms control.

Despite support for Article VI, including a British amendment to the text,\(^{(85)}\) and the perceived need for tangible progress to halt vertical proliferation, there appears to be some ambiguity about the extent of British participation in subsequent nuclear arms control processes. Mulley remarked that his government:

\[\text{accepts the obligations to participate fully in the negotiations required by Article VI and it is our desire that these negotiations should begin as soon as possible.}^{(86)}\]

Yet in a 1967 ENDC session Chalfont stated that:

\[\text{the great powers - and here I refer specifically to the United States and Soviet Union - are understandably very unlikely to begin to dismantle their own armouries while the possibility of what has been called "horizontal" proliferation still exists.}^{(87)}\]

At the NPT ratification ceremony the British Prime Minister observed that the NNWS had a right to expect that the NWS would fulfil their part of the bargain. But Wilson went on to say that, "we are confident that the American and Russian negotiators will bear this obligation in mind when they get down again next month to the complex discussions on the limitation of strategic arms."\(^{(88)}\) Indeed British nuclear forces were excluded from the SALT process. In other words nuclear arms control was, in practice considered the exclusive province of the superpowers. However, the British were prepared to take an active role in the non-nuclear arms control arena, Biological and Chemical weapons in particular.\(^{(89)}\) But even though the NPT and a Comprehensive Test Ban are relevant to Britain's
nuclear weapons programme, "there is no binding obligation to do anything more than enter into arms control negotiations with some serious intent." Furthermore, it should be noted that during the treaty negotiations care was taken to ensure that it contained no legal limitation upon continued Anglo-American transfers of strategic delivery systems and nuclear materials. Since the 1958 MDA and 1963 PSA were central to British military nuclear policy, it is unlikely that Articles I and II were intended to preclude or inhibit such co-operation. Although the Russians had tried to prevent existing NATO nuclear arrangements, they eventually acquiesced so that the dual-key arrangements and nuclear consultation were left unhindered. Moreover, whereas Article I and II prohibited transfer and receipt of nuclear weapons, exchanges facilitated by the MDA and PSA, which deal in materials and delivery systems are permitted. In short, the Nassau Agreement is not incompatible with the NPT as long as the transfer of missiles does not include warheads. This reinforces the point made in Chapter 3 that the British basically defined proliferation in horizontal rather than vertical terms. Despite public statements that the UK was ready to participate in nuclear talks, in practice the British government have ensured directly during the NPT negotiations, and indirectly during SALT, that the future of its nuclear forces were secured. This does not suggest a commitment to immediate arms reductions, or certainly not reductions affecting British nuclear arms.

Some of the NNWS in the ENDC feared that they would lose their bargaining power once they signed the treaty. However, the British supported the inclusion of Article VIII which made provision for a review conference. A Review Conference, as Mulley remarked would "be a weapon of persuasion in their hands." In fact the British suggested in an amendment to a draft text a provision of a conference to "review the operation of this treaty with a
view to assuring that the purposes of the Preamble and Provision of the treaty are being realised."(95) The Review Conference proved subsequently to be a potent weapon in the hands of the NNWS.

The thinking behind Britain's support for a Review Conference was made clear by Fred Mulley in October 1967:

Some of the measures listed in the eleventh perambular paragraph of the draft texts liquidation of existing stockpiles and the elimination from national arsenals of nuclear weapons and their means of delivery - can only be dealt with effectively in the framework of a treaty of general and complete disarmament.(96)

Indeed at the 1975 and 1980 NPTRCs Article VI issues proved to be the most contentious, and in 1980 prevented conclusion of a consensus substantive declaration. A Review Conference, however, would provide an opportunity to review, as the British suggested, the purposes of the preamble and provisions of the treaty.(97)

9. CONCLUSION

The NPT is the cornerstone of the non-proliferation regime and it is for this reason an understanding of the British position at the treaty negotiations is important. Articles III and IV are of special importance here. Given the political commitment by NNWS to forgo the weapons option, the fullest exchange of information, technology and services under safeguards could take place. The extent of British commitment to Article IV became more apparent in the 1970s, especially at the Windscale Public Inquiry, International Nuclear Fuel Cycle Evaluation and the IAEA Committee on Assurances of Supply.(98) Although Article VI has proved to be a major stumbling block at the 1975 and 1980 Review Conferences, in practice the British have
attached more importance to the provisions of Articles III and IV. Much more attention has been paid to the problems of reducing the risk of horizontal proliferation than halting the nuclear arms race. For this reason attention will be paid primarily to Britain and the civil-military relationship and how this affects the operation of Articles III and IV.
CHAPTER 9

NPT REVIEW CONFERENCES 1975, 1980: BRITISH ROLE AND OBJECTIVES

1. INTRODUCTION

As noted in Chapter 8 it was originally a British proposal that led to the inclusion of Article VIII, paragraph 3 in the final text of the NPT. This calls for a five yearly conference to "review the operation" of the NPT "with a view to assuring that the purposes of the Preamble and the provisions of the treaty are being realised". The first of these conferences opened in May 1975 five years after the entry into force of the treaty. The second was held in August and September, 1980. Both were held, as Article VIII specified, in Geneva. Each Review Conference was preceded by three Preparatory Committee meetings. These were primarily concerned with organizational and procedural matters rather than substantive issues; for example, the division of conference costs, chairmanship of main committees and agenda. For this reason the Prep. Comms. will not be discussed here. However, it is sufficient to note that as one of the three depository powers the British assumed a leading role. (1)

For the 1975 Conference three Prep. Comm. meetings were held between April 1974 and February 1975. The corresponding meetings for the 1980 conference were held between April 1979 and April 1980. Given the detailed pre-conference work it is logical to assume that the British had already begun to prepare and consider their position at more or less the same time. However the final delegation briefs would not have been drawn up until nearer the time. (2)

There is, however, a paucity of publicly available documentation on British thinking prior to and during the
Conferences. For this reason there is little option but to rely on the statements made by Ministers and officials during the Conference public plenary sessions. There are several disadvantages to this course of action. First, it takes no account of the deliberations of either the main committees and drafting committees closed sessions or coordinating meetings within the western group and between the depositary powers. Second, the diplomacy of the "back channel" or the margins of the conference cannot be ascertained from public sources. Finally, reliance on "declaratory doctrine", public statements, may be fundamentally misleading. Conversely, there are ready reasons for considering such public statements as a reasonable reflection of the British position. Since both Conferences worked on consensus which, for the purposes of this chapter, means that if the British did not subscribe to the views contained in the Final Document, then there would have been no document at all. Furthermore, given the attention to the maintenance of an agreed Whitehall position, and care given to the preparation of Ministerial statements, the speeches by the FCO Minister of State may be regarded as a plausible indication of British attitudes.

The composition of the British delegation at the 1980 Conference gives an indication of the range of interests involved. The FCO is the lead department in Whitehall on the NPT. Consequently the bulk of the delegation consisted of FCO personnel; for example, the British delegation to the Committee on Disarmament, the British representative at the IAEA, the Arms Control and Disarmament Department, the Arms Control and Disarmament Research Unit, and FCO Legal Advisers. In addition there were representatives from the MOD and Department of Energy.

For these reasons discussion of the British position will focus primarily on the statements made by Ministers and officials in the plenary sessions. Moreover, as a
depository power with a long-standing commitment to the treaty it may be plausibly assumed that the British did play an important role in the "hidden" work of both Review Conferences. (5) Given the British contribution to the actual negotiations of the treaty itself this is not an unwarranted assumption. The object of this section is to establish to what extent, if at all, British statements reflect and re-state previous non-proliferation policy. Secondly, the statements on British nuclear exports, safeguards and arms control policies will be examined in a similar light.

2. BRITISH OBJECTIVES

Given the British disappointment at the 1980 conference's failure to agree a substantive Final Declaration, it is logical to assume that the production of such a document was one of the British objectives. (6) Furthermore a reaffirmation of the value of the treaty for all states' security, and a balanced review of the treaty were interrelated objectives at both conferences. This can be established from the Ministerial speeches in the first week of both conferences.

3. 1975

David Ennals, Minister of State, recognised that although the treaty was by no means perfect, it should not be weakened at the Conference. Rather than seek amendments, the Treaty should be strengthened. In summarising the British views on the main issues in 1975 Ennals identified the basic objectives. These were:

(i) participants should reaffirm the treaty and attract the widest possible adherence to its principles and purposes;
(ii) the Review Conference should give whole-hearted support to the IAEA and an effective safeguards regime;

(iii) participants should make whatever contribution they could to greater assistance, especially to the Parties to the Treaty, in the peaceful uses of nuclear energy;

(iv) encouragement should be given to the establishment of appropriate international machinery in which all the implications of PNEs could be properly examined;

(v) participants should tackle the great issues of arms control and disarmament, nuclear and conventional, in a spirit of greater realism and urgency.^(7)

From the chapters on nuclear export policy and safeguards policy it can be argued that points (ii) and (iii) represent the core of the British position. As for Article VI British practical contribution was minimal even though they subsequently participated in the Tripartite CTB negotiations between 1977 and 1980. Although the British played an active part in the CCD and MBFR talks, the British nuclear force was excluded from SALT. Indeed Lawrence Freedman notes that during SALT I the Americans were lobbied by the British to ensure that no restrictions were placed on US freedom to transfer whole weapons systems or relevant technologies to Allies.^(8) As noted in Chapter 3 the British had, since the mid 1950s, taken the view the vertical proliferation did not lead to horizontal proliferation. Such a position was, therefore, not inconsistent. Although Ennals argued that non-nuclear arms control such as the Biological Weapons Convention fell within purview of Article VI,^(9) the neutral and non-aligned states regarded substantial nuclear arms reductions as the only way for the NWS to fulfil their Article VI
obligations. In 1975 Mexico and Yugoslavia in particular maintained this line almost to the point where the conference failed to produce a final declaration. The areas of nuclear arms control where the British could make a contribution, however, were outlined. It was the Labour Government's declared intention not to acquire a new generation of strategic missiles. However, as Freedman noted the British sought to ensure that there would be no "non-circumvention" or "no transfer" provisions in SALT which would foreclose future options. Second, negotiations for a CTB were regarded as first priority for the CCD. However, subsequent events were to overtake both these declarations. More will be made of this in discussion of the 1980 Review Conference.

The main focus of British non-proliferation policy centred on promotion of the benefits of civil nuclear power and control of the nuclear fuel cycle. This was made clear during the 1965-68 treaty negotiations, and development of British export policy in the 1960s. In 1975 David Ennals made clear the relationship between non-proliferation and the development of civil nuclear power. At the beginning of his speech Ennals noted that:

In endeavouring to control the risk of proliferation, the international community would find itself at odds with strong commercial and economic pressures. Obviously the simplest method of control would be to ban the further construction and sale of nuclear power plants but that would strike at the economies of many countries, including those of the developing countries which needed the assurance of nuclear power. It was therefore necessary to take account of economic realities and to attempt to perfect a system of non-proliferation without harming the legitimate interests of any country.\(^{(10)}\)

Two observations may be made here. First non-proliferation
policies based on technology denial are rejected. It is noted that this would strike at a state's legitimate interests. As noted in Chapter 8 Article IV was of particular importance for the treaty from the British perspective. The need for secure energy supplies is implicit here. Second, it was recognised that there was a need to reconcile the diverging interests of non-proliferation objectives and commercial and economic pressures. However, the British maintained that these interests are not irreconcilable; on the contrary, they can be mutually reinforcing.

Main Committee II was charged with amongst other things review of Article IV. During its deliberations Jackson, UK Representative to the IAEA in Vienna, reiterated British support for Article IV objectives. In particular reference was made to the relationship between it and Article III A(2) of the IAEA statute. Jackson went on to detail the level of British financial contribution to the IAEA's Technical Assistance Programme, and the growth in the level of British support for the IAEA's General Fund. This had increased from $15,000 in 1971 to almost $250,000 in 1975. Moreover, on the distribution of these resources and access to British nuclear exports, the British were prepared to agree that there should be some preference in favour of states party to the NPT. There would be no preferred market, however. Non-parties such as Argentina, Brazil and India had not found their civil programmes restricted by non-membership of the NPT. But as Ian Smart noted, "it was of some importance that the British announced that they would restrict at least a part of its nuclear aid through the IAEA to recipients who had accepted the NPT as a whole." Nuclear services, for example, would continue to be made available to non-parties. Although the Neutral and Non-Aligned argued that there should be no trade whatsoever with non-parties the British only conceded the principle that parties should benefit but were not prepared to exclude non-NPT
states. This, of course, suited the interests of the British nuclear industry. However, it was maintained that denial would make such states less amenable to non-proliferation objectives. Moreover, as such threshold states themselves were on the verge of becoming suppliers in their own right it was important to cultivate a responsible attitude.

The British line on Article IV issues in 1975 was not at odds with the views and interests expressed during the negotiating process of the NPT itself. The Final Declaration section on the Review of Article IV reflects this; for example, the substantive Final Declaration noted in its second paragraph that:

The Conference reaffirms, in the framework of Article IV2, the undertaking by all parties to the treaty to facilitate the fullest possible exchange of equipment, materials and scientific and technological information for the peaceful uses of nuclear energy and the right of all parties to the Treaty to participate in such exchange and welcomes the efforts made towards that end.\(^{15}\)

However, it was never intended that nuclear technology and materials should be made available without some form of control. Article III called for IAEA safeguards on all facilities and materials of all NNWS party to the treaty. The objective here was not to obstruct or prevent nuclear trade, but rather make it easier. Suppliers required assurance that their exports would not be diverted for military purposes. Safeguards would not only reassure suppliers, but also all states. They would then know that nuclear trade was conducted in a stable and uniform manner. It is clear from the Conference plenary sessions that IAEA safeguards were central to the British position on the relationship between nuclear exports and non-proliferation. For the British:
The central object of the treaty was to prevent the proliferation of nuclear weapons, but another of its objectives was to ensure that the benefits of nuclear technology should be available for peaceful purposes to all Parties to the Treaty... (the UK) fully accepted that fundamental principle, which of course, involved the application of IAEA safeguards.(16)

Despite this the British were not prepared to impose or insist on full-scope safeguards on nuclear exports to non-NPT states. However, it would be preferable, but until such times as states outside the treaty could be persuaded to accept full-scope safeguards and other suppliers to require them as a condition of export, INFCIRC/66 type safeguards agreements would have to suffice.(17) Whereas INFCIRC/135 required safeguards on all materials and facilities in a NNWS, INFCIRC/66 only required safeguards on specific items exported to a NNWS. The Final Declaration on Article III covers this important aspect of British policy. The Conference urged that, "in all achievable ways common export requirements relating to safeguards be strengthened in particular by extending the application of safeguards to all peaceful nuclear activities in importing states not party to the Treaty", and that "such common requirements be accorded the widest possible measure of acceptance among all suppliers and recipients."(18) Uniformity and predictability for safeguards and exports would best secure the interests of non-proliferation by removing safeguards from commercial competition. This was the principal objective of British policy at the NSG meetings.

Notwithstanding Yugoslav criticism of the NWS alleged failure to fulfil their Article VI obligations, the 1975 Conference agreed to produce a Final Declaration. The development of the Conference is not as important, for the purposes of this chapter, as the articulation of British views which can be established from the Plenary sessions.
and Final Declaration. One final point emerged in 1975 which was to become part of the relationship between British export and non-proliferation policies. It was announced at the second plenary meeting of Main Committee II that in, "the opinion of the UK delegation the IAEA should continue its study on the question of regional nuclear fuel centres."(19) More will be made of this in the discussion of the 1980 Conference and in Chapter 12.

4. 1980

The 1980 Conference followed the same procedures as its predecessor. For the purposes of this section most of the discussion will be devoted to British statements. However, the 1980 Conference was unable to produce a consensus Final Declaration. This was largely a consequence of NNWS dissatisfaction with, in their view, the failure of the NWS to fulfil their side of the bargain. Neither superpower or the British were able to subscribe to language which was overcritical of them or sought to impose new and unworkable obligations on them. There were, however, additional reasons for the failure to produce a consensus declaration. A SIPRI commentator identified the poor state of East-West relations, Soviet intervention in Afghanistan and social unrest in Poland in particular, as contributory factors.(20)

As in 1975 the British had more to say about Articles III and IV than Article VI. For example, one of the British objectives was identified as the need to ensure a common determination to work for a new consensus on nuclear trade providing improved access to the peaceful benefits of nuclear energy under non-proliferation provisions. This was outlined in the August 1980 issue of the FCO's Arms Control and Disarmament Research Unit's Newsletter. Indeed, the statements in the Plenary sessions are broadly similar to those made in 1975. Crucially the relationship between British domestic policy objectives and experience is clear
from the British statements.

Douglas Hurd, then Minister of State, delivered the major British statement on 12 August. A specific effort was made to defend and explain the purposes of the Nuclear Suppliers' Group which had been the subject of NNA criticism. In their view the NSG was a cartel designed to deny underdeveloped states the benefits of civil nuclear power. Moreover, the NSG safeguards guidelines were, in their view, in breach of Article IV.\(^{(21)}\) For the British, however, the objective of the NSG guidelines had been to:

> introduce predictability and to reduce competition between suppliers on safeguard requirements, a form of competition which was liable to damage the non-proliferation regime and the interests of Parties to the Treaty. The guidelines did not inhibit normal competition and relating to the commercial conditions for the supply of nuclear materials, equipment and technology.\(^{(22)}\)

Underlying this objective was the recognition that unpredictability in the world nuclear market and minimal safeguards requirements for nuclear exports threatened the non-proliferation regime. States might be tempted to undercut competitors by offering materials and technology with minimum safeguards. Developments which encouraged autarkic nuclear programmes, or exposed safeguards to commercial competition were not conducive to a stable non-proliferation regime. As noted above an unreliable and unpredictable supplier, the US, had helped to shape the objectives of the domestic British programme. In the 1940s and again in the mid 1960s American actions threatened the integrity of the British civil and military nuclear programmes.

In an attempt to address the problems created by the NSG, and US non-proliferation policy under President Carter (see
Chapters 6 and 11) the British recommended the Review Conference to support a major initiative within the IAEA. The interests of both supplier and customer would be accommodated by strengthening Article III and Article IV provisions. Hurd noted that INFCE had done much to foster the spirit of co-operation in the nuclear world which was important to preserve. This had been an important preliminary step. The next step, according to the British, was taken in June 1980 by the IAEA Board of Governors. This led to the establishment of a:

Committee open to all member states to consider and advise the Board on the linked issues of assurance of supply and mutually acceptable non-proliferation conditions.

For the British:

the work of the Committee must proceed from a recognition of the very close relationship between acceptance of IAEA safeguards and the availability of nuclear material, equipment and technology: IAEA was well qualified by experience to tackle the nexus of problems.\(^{(23)}\)

Furthermore, the British proposed language for the Final Declaration on Article IV which made clear the level of British support for the Committee on Assurances of Supply:

The Conference stresses the importance of using the Committee on Assurances of Supply to develop as wide a consensus as possible on the closely linked issues of nuclear trade and non-proliferation and urges all parties to the treaty to make a full contribution to its work.\(^{(24)}\)

The emphasis placed on the assurance of nuclear supplies in British policy is derived from two separate factors.
First, avoidance of uncertainty and unpredictability in the nuclear market would enhance, rather than threaten the security of the non-proliferation regime. Uncertainty would encourage independent nuclear programmes outwith the IAEA safeguards system. Second, the proposals for assurance of supply closely corresponded to the interests of the British civil industry, BNFL in particular. This had become clear at the Windscale Inquiry and at INFCE (see chapters 6 and 11). At the 1980 NPTRC Ian Cromartie, who was then the UK’s Resident Representative to the IAEA, made this clear during Main Committee II discussions on Articles III and IV:

account must also be taken of the fact that for a number of countries at an early stage of nuclear development, the question of sensitive materials had little economic sense in the short term; as pointed out for the Evaluation such countries were more interested in ensuring reprocessing and enrichment services than in building facilities for that purpose themselves and the Evaluation had also suggested that plutonium recycling and the widespread use of breeder reactors would be of little economic value in the short term. What most countries needed, however, was assurance of supplies with respect to non-sensitive items, such as nuclear fuel and equipment and the fuel cycle services required for the operation of reactors. (23)

As noted in Chapters 5 and 6 the provision of enrichment and reprocessing services for overseas customers was a major factor in the decisions to establish URENCO and to build THORP. It appears as if non-proliferation objectives happily correspond to British civil nuclear programme objectives; the provision of fuel cycle services for customers worldwide. However, the "assurances" factor worked both ways. It was essential for supplier states to ensure that their exports were adequately safeguarded.
Recognition of this factor by importers would ensure secure fuel supplies and access to non-sensitive equipment. CAS would, therefore, ensure that the interests of secure supply and non-proliferation were not compromised by ill considered pursuit of only one aspect of this dual policy.

Cromartie made this plain enough at the Conference:

As a country which was both a supplier and consumer of nuclear energy, the United Kingdom welcomed the establishment by the IAEA of the Committee on Assurances of Supply, which would make it possible to ensure greater stability in international nuclear trade. That new effort indicated a recognition of the close relationship between the acceptance of non-proliferation conditions and the availability of nuclear material, equipment and technology. The new committee should devote itself to building for the future a consensus on as wide a basis as possible on international trade and non-proliferation.\(^{(26)}\)

In 1975 the British had cautiously expressed support for the RFCC concept. In 1980 Cromartie almost went as far to endorse a Department of Energy commissioned paper on multinational arrangements for the nuclear fuel cycle.\(^{(27)}\) Such concepts, moreover, would fit in very well with both URENCO and THORP. More will be made of this in Chapter 12.

The British position on Article IV at the 1980 Review was not only consistent with previous policy, but confirmed the relationship between the civil programme's objectives and those of British non-proliferation strategy. Moreover, the public statements in 1980 were a clear articulation of the objectives of the NPT itself.

Although full-scope safeguards were, for the British, an ultimate objective, there was no question of making FSS a pre-condition on all nuclear exports. The reasons for this
were similar to those which underpinned British support for CAS, and reluctance to support a preferred market for NPT states. Indeed the working paper on CAS also called for all NPT states to bring about an extension of IAEA safeguards to all nuclear activities in all NNWS outside the NPT. In short, unreasonable insistence on safeguards was more likely to undermine rather than enhance non-proliferation objectives. However, it was hoped that the Conference would stress the desirability of full-scope safeguards for all NNWS outside the NPT. This would have to result from persuasion rather than diktat. The best way to do this would be to demonstrate that rather than obstruct or hinder a state's economic or technological development safeguards, but particularly full-scope safeguards, would "greatly facilitate the use of nuclear energy for peaceful purposes." During the Conference's third week Cromartie made the British position clear. Its relationship to Article IV and CAS objectives are evident:

The acceptance of full-scope safeguards by all NNWS would greatly increase worldwide confidence that the peaceful uses of nuclear energy were not being abused as a cloak for the development of nuclear weapons and other explosive nuclear devices. That increased confidence would make possible freer trade in nuclear materials, which would in turn promote the use of nuclear energy for peaceful purposes, to meet the world's growing need for energy (the British) delegation therefore considered it important that the Conference should urge all non-nuclear weapon states not party to the Treaty to submit all their nuclear activities to IAEA safeguards and urge all parties to work for a situation in which full-scope safeguards were a part of the generally accepted pattern of international nuclear trade.

Even though NNA states such as Yugoslavia and the
Philippines complained that non-parties had access to nuclear technology under less than full-scope safeguards and that this situation should be reversed, the British declined to require full-scope safeguards on their nuclear exports.

As in 1975 the most contentious issue was arms control. Mexico, Sweden, Nigeria and Yugoslavia in particular argued that the NWS had singularly failed to fulfil their side of the NPT bargain. For such states this fact had to be reflected in the Final Declaration. However, none of the NWS were prepared to concede language which satisfied the grievances of the NNA states. This was the main reason for the Conference failure to produce a consensus Final Declaration. Although Douglas Hurd recognised the need for progress in nuclear arms control in his speech, in practice as noted in Chapter 3, the British saw no connection between the existence of their own nuclear force and further weapons proliferation. The British did not participate in the SALT negotiations; indeed, a major preoccupation was to ensure the exclusion of British nuclear forces from any SALT provisions.

The British, however, were party to the Tripartite CTBT negotiations. A report of the progress was co-presented at the conference by the three NWS party to the Treaty. Despite significant accomplishments the Report noted that there were still important areas where substantial work was still to be done. These covered verification issues. Although there was no legal obligation for the NWS to produce a CTBT, for many NNA states a CTBT was the litmus test of NWS commitment to the NPT. As noted above the Group of 77's Working Paper had a great deal to say about the need for such a treaty. The NNA sought the establishment of an ad hoc working group in the CD to start multilateral negotiations for a CTB, and to proclaim a simultaneous unilateral moratorium or a trilateral moratorium on nuclear testing. This was particularly
unpalatable to the British presumably because the Trident decision announced in July 1980, necessitated continued testing. Since Committee II was able to agree consensus language on Article III and IV issues, the Article VI provisions on CTBT especially, prevented an agreed Final Document. However, this needs to be put into perspective. As Julie Dahlitz notes there was no repudiation of the Treaty. Instead the Group of 77 affirmed their adherence to the principles of the Treaty. Despite the centrality of arms control objectives in the NNA's view, the British in practice had much more to say about Article III and IV issues. The reason for this is straightforward. In the British perspective the principal objective of the NPT was the prevention of further nuclear weapons states. Vertical proliferation was peripheral to this objective. Furthermore, since proliferation was thought of largely in "horizontal terms", it was logical that more attention should be devoted to Articles III and IV; that is, safeguards and availability and spread of civil nuclear technology.

5. CONCLUSION

Neither the 1975 or 1980 Review Conferences represented any fundamental departure from British non-proliferation policy. The views articulated on Articles III and IV in particular were echoed in other non-proliferation fora, such as INFCE, in the late 1970s by British representatives. In short, the relationship between Article III and IV remained fundamental to British non-proliferation policy.
CHAPTER 10

BRITAIN AND THE IAEA/EURATOM SAFEGUARDS SYSTEMS

1. INTRODUCTION

For the purposes of this section the 1952-1982 period will be divided into two parts. The first covers the years from the IAEA's formation in 1957 to 1967 when the British government offered to place its civil facilities under safeguards. The second covers the entry into force of Euratom safeguards in 1973 and the Tripartite safeguards agreement between the IAEA/Euratom and UK in 1974. These years witnessed not only the greatest expansion of civil nuclear power worldwide, but also a simultaneous expansion in the coverage of IAEA safeguards. Three issues will be discussed within this time scale: (i) application of safeguards to UK facilities, (ii) UK attitude to IAEA safeguards on nuclear facilities and materials overseas, and to British nuclear exports, and (iii) British contribution to safeguards technology and procedures.

When Eisenhower launched the Atoms for Peace programme he also envisaged the establishment of an international agency to promote and control the benefits of the peaceful atom. The International Atomic Energy Agency was established in 1957. However, until the early 1960s more attention was focused on the promotional rather than safeguards aspects. There was opposition to the safeguards concept from developing countries, India in particular. The Soviet Union also opposed them. However, once this opposition abated the way was clear for the safeguards system to develop. In 1965 the IAEA was able to produce a new set of guidelines for inspections and procedures. These were incorporated in Information Circular - INFCIRC/66. With subsequent additions INFCIRC/66 formed the basis for all IAEA safeguards agreements with states not party to the NPT, and Treaty of Tlatelolco. Once the NPT entered
into force it was necessary to develop a more comprehensive framework to satisfy the requirements of the NPT's Article III. This culminated in INFCIRC/153 which is the basis for all safeguards agreements with NNWS party to the NPT. The objective of this system is to "follow the flow of nuclear material through a plant, and not the plant itself". The British took the lead in promotion this concept. Both INFCIRC/66 and INFCIRC/153 are based on three essential methods of verification. Since 1965 the safeguards system has not only expanded in scope, but also in technological sophistication. It now has safeguards procedures for the key fuel cycle processes, enrichment and reprocessing. By and large this expansion has matched the world-wide expansion of civil nuclear power. However, the single most important impetus was provided by the NPT. All NNWS parties were required to conclude a safeguards agreement with the IAEA covering all their nuclear facilities and activities. The agreement had to enter into force 18 months after negotiations between the Agency and state had started.

2. 1957 - 1967

(i) Application of safeguards to British facilities

Until 1963 the British regarded safeguards as only relevant for NNWS. During the drafting of the IAEA statute in Washington in 1954 and 1955 the British played a leading role by virtue of being one of the most advanced civil nuclear powers. Sir Roger Makins, then Chairman of the UKAEA, was the British representative on the international committee which drafted the statute. Although the IAEA was, in its early years more concerned with the promotion rather than control of nuclear energy, the British and Americans included clauses in the Agency statute which would enable a check to be kept on fissile material supplied to NNWS. Indeed the British, along with the US, Canada, South Africa and Australia made a major
contribution to the IAEA's first safeguards agreements those with Japan, INFCIRC/3 in 1959, and INFCIRC/261, 1961.\(^9\)

In 1961 the US decided to place four of its nuclear plants under IAEA safeguards. Two years later the British decided to follow the US example. The CEGB's Bradwell Magnox station however was not opened to the IAEA until 1966. However, both the UKAEA and Ministry of Technology, which had assumed responsibility for nuclear energy in 1964 were hostile to the idea.\(^10\) Amongst other reasons it was felt that the limited size of the IAEA inspectorate would be stretched to the limit if it had to safeguard materials in NWS as well as in NNWS.\(^11\)

The December 1967 decision to submit British civil stations to safeguards was taken largely to expedite progress in the NPT negotiations which had foundered on the safeguards requirements. Not only did the LDCs harbour doubts about safeguards, leading industrialised states Japan and the FRG in particular, considered the type of safeguards envisaged as a licence for commercial espionage.\(^12\) The British offer to open its civil plants was taken "in order to encourage widespread adherence ... to the NPT by demonstrating to non-nuclear weapons states that they would not be placed at a commercial disadvantage by reason of the application of safeguards under the NPT".\(^13\) Commitment to the NPT was sufficient to overcome internal opposition to safeguards in the UK. However, the December offer was conditional. British facilities would not be subject to IAEA inspection until, "such time as international safeguards are put into effect in the non-nuclear weapon states in implementation of the provisions of a treaty."

Moreover, this was subject to the exclusions for national security reasons only.\(^14\) For example, the eight military reactors and the Windscale reprocessing plant were excluded. Indeed, provided the IAEA were notified, the eventual agreement permitted the British to transfer
safeguarded fissile material to military purposes. Existence of dual purpose facilities and the incomplete safeguards coverage was a source of conflict between the British government and Euratom in the 1970s and 1980s.\(^{(15)}\)

Safeguards in the UK are not intended to prevent diversion of civil material to military purposes, but rather to demonstrate that safeguards would not damage either commercial operation of nuclear plants or compromise confidential design information. As Britain already was a weapon state there was no requirement to demonstrate a clear separation of civil and military facilities. Although this was recognised as desirable and eventually became reality as the civil programme became increasingly separate, the British were not prepared to subject themselves to full-scope safeguards as long as some connections obtained. It should also be noted that application of IAEA safeguards to British facilities would serve as a test bed for IAEA procedures and technologies.

The CEGB Magnox station at Bradwell was opened to IAEA inspection in October 1966.\(^{(16)}\) This, however, was an isolated event. Although there were several inspections at Bradwell, there were no further IAEA physical inspections of CEGB/SSEB facilities. INFCIRC/86 was designed to enable the IAEA to develop procedures and familiarization with a Magnox type reactor.\(^{(17)}\) However, the plutonium extracted from Bradwell's irradiated fuel was subsequently used in a zero energy fast reactor (Zebra) at Winfrith, but the fuel remained subject to IAEA safeguards.\(^{(18)}\) The Agency had access to both the reactor and its operating records. Zebra was also on the IAEA designated list between 1974 and 1979.\(^{(19)}\) Whilst Bradwell was open to inspection the IAEA visited the reactors several times a year and obtained records of natural uranium fuel element input, and the power generated in the fuel elements before they were sent to Windscale for reprocessing.
(ii) British attitude to safeguards in other states

The Magnox reactors exported to Italy and Japan were subject to Euratom and bilateral safeguards respectively.

Article VIII of the inter-governmental agreement between Italy and the UK required the former to ensure that any material or equipment was employed solely for peaceful purposes.\(^{(20)}\) In 1962 the US decided to transfer responsibility for administering its bilateral safeguards agreements to the IAEA. These had been concluded with non Euratom states in the 1950s. Willrich and Taylor note that this and parallel British and Canadian efforts, "were largely responsible for the marked expansion in the applicability of the IAEA safeguards system during the years which preceded the NPT".\(^{(21)}\) Indeed the British supplied Japanese Tokai Mura reactor was the first large scale commercial power station outside the NWS to come under IAEA safeguards.\(^{(22)}\) Prior to the eventual transfer to the IAEA, covered by INFCIRC/107, of 26 September 1967 inspections were carried out by the UKAEA.\(^{(23)}\) Bilateral safeguards agreements for UK supplied research reactors in Denmark and Australia were also transferred to the IAEA.\(^{(24)}\) However, these agreements covered only specific supplies of material or equipment. They were not full-scope safeguards agreements, rather they were based on INFCIRC/66.\(^{(25)}\) In 1969 the Herald research reactor supplied to Chile was from the outset subject to IAEA safeguards.\(^{(26)}\) IAEA safeguards were, and remain, a prior condition for all British nuclear exports, INFCIRC/66 being the minimum acceptable.

At no time was it intended that safeguards should obstruct the development of civil nuclear power, rather they were designed to provide a framework in which trade in nuclear equipment and materials could proceed and be made easier. This, at least, was the British perception. Nuclear trade could not proceed unhindered without assurances acceptable
to all states that ostensibly civil facilities and materials would not be used for military purposes.

(iii) British Contribution to Safeguards Technology and Procedures

Generally the major developments in safeguards technology did not occur until the 1970s. As one British official responsible for safeguards policy observed, safeguards technology was non-existent in the early 1960s. Until the mid 1960s IAEA experience was confined to small research reactors. As noted above both the American and British decisions to open large power reactors to inspection afforded the IAEA valuable experience. Indeed this became the basic IAEA criterion for inspecting designated British facilities. For this reason CEGB/SSEB reactors were not usually physically inspected.

In August 1967 the IAEA established an advisory panel on safeguards techniques to advise the Board of Governors on the priorities for research and development that would be necessary. Seven advanced nuclear states, including the UK, in addition to recommending techniques for safeguards application also discussed the problems likely to arise when safeguards would have to be applied to bulk handling facilities - enrichment and reprocessing. Reprocessing plants were discussed in detail the following year. Unlike reactors fuel cycle plants are more difficult to safeguard given the flow of materials in gas or liquid state. More work was devoted to enrichment and reprocessing plants in subsequent years.

3. 1967-1982

(i) Applications of safeguards to British facilities

The entry into force of the NPT in 1970 and the signing of the Treaty of Tlatelolco provided the biggest boost to the
IAEA safeguards system. For example, in 1971 there were nine nuclear power stations containing nuclear material under Agency safeguards whereas the comparable figure for the end of 1982 was 143.\(^{(30)}\) It should also be noted that civil nuclear power made its greatest expansion between 1967 and 1977. The coverage of safeguards expanded in tandem.

One of the most contentious issues during the NPT negotiations was the relationship between Euratom and IAEA safeguards. The British had to make a choice between antagonising Euratom states or compromising support for the IAEA.\(^{(31)}\) But as events worked out there was no need to choose between the two systems. British accession to the EEC on 1 January partially resolved the problem. As a consequence BNFL plants and installations became subject to Euratom safeguards.\(^{(32)}\) CEGB/SSEB reactors were similarly affected; indeed, the CEGB Annual Report of 1973-74 noted that fuel stocks statistics and movements were sent to Luxembourg each month, and that a number of Euratom safeguards inspections had already taken place.\(^{(33)}\) Between 1973 and 1984 BNFL's fuel fabrication plant at Springfields was visited on 28 occasions by Euratom inspectors. Windscale was visited on sixty occasions.\(^{(34)}\) Despite this there was one area where there was conflict between the British and Euratom. British status as a NWS was at the root of the problem. Lack of direct access to the Sellafield (Windscale) reprocessing line was the focus for conflict. Since civil and military materials are co-processed in the same plant, the Government could not accept physical access to the reprocessing line. This would, or so it was argued, reveal sensitive military information. Although Euratom had access to the civil records of material passing through the plant, they did not have physical access to verify the flow.\(^{(35)}\) Access was denied because as Hugh Sturman of BNFL noted it, "would give them access to other information which we are instructed not to reveal".\(^{(36)}\) Negotiations between
Euratom and the British continued throughout the 1970s; however, by the end of 1984 the problem was still not resolved. A similar problem applied to Springfields, but this was resolved. (37)

The problem is primarily attributable to historical circumstances and the long standing obsession with official secrecy, especially on atomic information. Although British officials would concede that ideally the civil and military programme should be completely separated, the nature of the British nuclear programme precluded such an option. However, in the years since the 1950s the civil and military programmes had become further apart. Reprocessing was the last link. However, the thermal oxide reprocessing plant (THORP) scheduled to come on stream in 1990 would be open to safeguards. Indeed safeguard considerations, ease of access for example, were taken into account at the design stage. It was intended that THORP would be used for civil purposes only. Indeed since THORP was proposed largely with the overseas market in mind, military use would interfere with its economic use.

Even though there was no Euratom/IAEA access to the reprocessing line this did not really matter. Dr. Donald Avery, representing BNFL at the Sizewell B Inquiry noted that "the civil accounts are subject to safeguards in the sense that the inputs and outputs of plutonium on the civil stream have to be declared to Euratom and through Euratom to the IAEA". (38) However, a former CEGB scientist Dr Ross Hesketh argued both before and during the Sizewell Inquiry that safeguards in the UK were a sham since it was possible for plutonium from civil stocks to be moved into the military stockpile without the Euratom or IAEA knowing. (39) It was further alleged that civil plutonium had been transferred to the US under the Mutual Defence Agreement of 1958-59, and had been used in nuclear weapons. Indeed approximately two tonnes of plutonium were in destinations other than those admitted by the British
government.(40) Lord Hinton, first chairman of the CEGB, went as far as to suggest that the CEGB was telling lies to the Sizewell Inquiry by denying the military use of plutonium produced in the Board's reactors.(41)

It is important in this case to re-examine the purposes of safeguards in the UK. As a weapon state safeguards are not intended to prevent diversion of civil material to military purposes. Instead the objective is to demonstrate that there are no commercial disadvantages or burden on operators accepting safeguards. This is certainly the perception of British officials. Indeed it was conceded that it was perfectly possible for "atoms of civil plutonium to find their way into the military programme and vice versa during co-processing". This did not matter as long as x tonnes of 'civil' plutonium entered the reprocessing line and x tonnes of 'civil' plutonium emerged at the other end. What really mattered was the efficacy of safeguards in NNWS; what the British as a weapon state did with their fissile material would not influence the behaviour of other states. The British position on safeguards in the UK is thus influenced by British status as a NWS and the practicalities and economics of reprocessing.

The UKAEA's fast reactor and reprocessing plant at Dounreay were inspected by the IAEA between 1980 and 1981. Dounreay was designated by the IAEA because as an advanced reactor the Agency would derive useful experience from inspecting such facilities. Two years were all that was required for this purpose.

It is worth briefly noting some of the steps taken by Britain in the safeguards field in the early and mid 1970s. In December 1972 the British had unilaterally placed certain nuclear activities under IAEA safeguards.(43) On June 16, 1976 the IAEA approved an agreement with the UK and Euratom.(44) However, INFCIRC 263 did not enter into
force until 14 August, 1978.\(^{(45)}\) Until then the IAEA applied safeguards in the UK only in cases when so required by agreements involving third countries or under special arrangements.\(^{(46)}\)

Although there were problems with access to the British reprocessing plant, parallel efforts with uranium enrichment were much more successful. The ultra centrifuge process used by URENCO posed a particularly demanding technical challenge to safeguards technology. Furthermore, commercial considerations, design information especially, complicated the issue since access to the sensitive parts of the process was unlikely to be yielded by the operators. There was, however, no military problem since the MOD decided to build their own smaller gas centrifuge at Capenhurst to provide HEU for SSBNs and SSNs.\(^{(47)}\)

Although the general principles for fulfilling safeguards obligations were easily established, since the physical simplicity of the process permits accurate material accountancy and measurements, elaboration of this approach was considerably more difficult.\(^{(48)}\) The Hexapartite Safeguards Project was established in November 1980 by Australia, Euratom, IAEA, Japan, URENCO, and the US. After two years discussion the project produced an inspection regime for the sensitive cascade halls based on "limited-frequency unannounced access". Programmes to demonstrate particular aspects of safeguards were also prepared. The most extensive of these was undertaken jointly by the UK, the IAEA and Euratom. As Dr Fred Brown notes the distribution of nuclear materials in an operating plant, measurement techniques and errors, and physical inventory procedures and accuracy were all shown to be in accordance with the various submissions and predictions given to the Project.\(^{(49)}\) However, BNFL's gas centrifuge plant was not fully subject to safeguards until September 1985 although it had participated in some preliminary tests.
(ii) British attitude to safeguards in other states

British nuclear export policy was outlined by the Foreign Secretary in March 1976. Whilst particular care would be taken with proposals to export sensitive equipment or technology, enrichment and reprocessing especially, IAEA safeguards would have to be applied to all other exports. James Callaghan announced in a written parliamentary answer that:

> our detailed requirements will include the application of IAEA safeguards or comparable safeguards which are verified by the IAEA to exported nuclear equipment and material; an assurance that whatever we export will not be used to manufacture nuclear explosives for any purposes.\(^{50}\)

Although the British accepted the desirability of full-scope safeguards, they would not be made a prior condition of British exports. As noted in Chapter 6 the British did not want to put their fuel cycle business at risk.

Neither BNFL nor the NNC were permitted to export fuel or reactors without prior government approval; indeed, both companies preferred clear guidelines as to whether business with particular overseas customers was possible. Neither was keen to proceed with the expense of placing tenders only to have the Government subsequently refuse permission.\(^{51}\) In the words of one senior industry official his company "did not behave like used car salesmen". The longlead times necessary for delivery of fuels or reactors preclude rapid underhand sales.

All imported irradiated fuels stored at Sellafield for reprocessing are subject to Euratom/IAEA safeguards.\(^{52}\) In 1984 there were six cameras and five video recorders installed at Sellafield oxide storage ponds.\(^{53}\) Ten years before the British, Americans, and Russians
announced that they would henceforth provide the IAEA on a continuing basis, with information regarding nuclear materials exports and imports out of and into their respective countries. (54) However, this move was a direct response to the May 1974 Indian nuclear test. This suggests that it was recognised that existing safeguards provisions needed to be strengthened. However, safeguards were and are a necessary adjunct of British nuclear exports. There is no contradiction between safeguards and non-proliferation objectives and the export of nuclear materials and hardware. Nevertheless it is highly unlikely that the British would have exported either enrichment or reprocessing plants even though both the French and West Germans were prepared to do so in the mid 1970s. It was better for BNFL to provide these services to customers overseas.

Despite the desire to export fuel cycle services and power reactors, the line is drawn at particularly sensitive technologies. However, this had not always been the case as the UKAEA had been prepared to supply a gaseous diffusion plant to France and reprocessing plants to Italy and Japan. During the 1970s the government prevented the UKAEA and BNFL from supplying South Africa and Brazil with uranium hexafluoride conversion plants. (55) There was also unease when the FRG decided to supply Brazil with a complete fuel cycle in 1975.

In 1975 the British came to the view that full-scope safeguards should become the norm. At the UN and at the IAEA Board of Governors non NPT states were urged to accept safeguards on all their nuclear facilities. (56) The following year the British proposed a new type of safeguards agreement at the IAEA broadly in line with Callaghan's UN announcement. Non NPT states should be asked to accept INFCIRC/153 type safeguards, as required by the NPT, without having to sign the Treaty. It was hoped that such a measure would eliminate the problem of "unfair"
competition between exporting countries. This had led to some suppliers losing contracts because they required stricter safeguards guarantees from the customer.\(^{57}\) Indeed the British complained at the UNGA Thirty-third session that for some years they had made a financial sacrifice in not exporting some civilian nuclear equipment, materials and technology because of a fear of adding to the proliferation of nuclear weapons.\(^{58}\) The objective here, as with the NSG, was to remove safeguards from commercial competition. IAEA safeguards, full-scope safeguards, were crucial to reconciling non-proliferation objectives with the "equally important commitment" under Article IV to further the development of nuclear energy for peaceful purposes. Protection of British commercial interests was equally important here. Safeguards should be made as watertight and non-discriminatory as possible. This was the reason for British support for full-scope safeguards.\(^{59}\) But as noted above there was no question of insisting on full-scope safeguards. This would only lose contracts for BNFL or the NNC; moreover, such measures were counterproductive. Britain's own experience counselled against such a policy. American insistence on safeguards on LEU for British AGRs even though unsafeguarded HEU was being supplied for military purposes was considered unacceptable. American intransigence was one of the reasons which led to the formation of URENCO which was designed to provide Europe with an independent source of LEU.

Ordinarily export licences were required for nuclear materials and equipment. In the early years a licence was required to export nuclear materials to any destination under the terms of an export order issued by the Board of Trade. This system remained in force throughout the 1952-1982 period. In 1982 the Department of Trade and Industry was the responsible government department in consultation with the FCO, MOD and DEN. There were problems with this system because "grey area" components were excluded;
that is, components and materials with no obvious nuclear use, but which could be incorporated into fuel cycle plants or nuclear weapons. An incident came to light in the 1970s which indicated that insufficient attention had been given to this problem.

It became clear that a Pakistani national, Dr. Qadir Khan who was working at the URENCO Almelo plant, stole confidential information. The Pakistani government had made an elaborate attempt to acquire technology and components for a gas centrifuge plant and UF6 conversion plant. Normally nuclear items were subject to the Export of Goods (Control) Orders. These were constantly under review and added to. Applications for licences were given the closest scrutiny by the relevant Whitehall departments, the FCO, MOD, DTI and Department of Energy. However, the system was not as rigorous or comprehensive as made out.

A special works organisation of the Pakistan government's ordnance service set out to purchase centrifuge components in Western Europe from a list of companies supplied by Khan. The British company involved was Emerson Electric Industrial Controls of Swindon. It supplied high frequency inverters. However, this deal came to light and an export-of-goods-control order was placed on the components on 9 November 1978. Despite this Nucleonics Week claimed that it was the company which drew the government's attention to the deal, but nothing effective was done about it. Norman Lamont noted that following the possibility of British manufactured frequency changers being supplied for use overseas in nuclear applications it was decided on 19 October, 1978 to impose export controls on those invertors capable of multiphase electrical output of between 600 and 2000hz. Nevertheless, it was reported that BNFL was aware of Pakistani interest in November 1976 and informed the government in December. There was an investigation but no action was taken until
October 1978.\(^{(65)}\) Subsequently export licences were imposed for equipment used in UF\(_6\) conversion plants, including mass spectrometres and pressure gauges.\(^{(66)}\) Indeed the whole incident led to a fresh review of equipment requiring an export licence. On 12 February 1979 "parts, components and subassemblies" of inverters were subjected to similar control. Tighter controls were imposed the following month when, "equipment specially designed for the manufacture or assembly of gas centrifuges capable of isotope enrichment and specially designed parts for such centrifuges were additionally subjected to control".\(^{(67)}\) In short, the Khan incident suggests that a determined state will acquire the necessary technology and equipment for its nuclear programme. The amendments to the Export of Goods (Control) orders were after the fact measures. But as Nucleonics Week commented, "the British appear to have locked the stable door after the horse has bolted".\(^{(68)}\) Nevertheless this incident does not indicate a fundamental inattention to non-proliferation objectives since neither nuclear equipment or materials were stolen or exported without licences. Grey area technology is difficult to control; indeed, "after all, an inverter is a pretty innocent piece of equipment".\(^{(69)}\) It was conceded, however, there had been a breach in security at Almelo which in the British view should never have been allowed to happen. This was made plain to the Dutch authorities.\(^{(70)}\)

(iii) **British contribution to safeguards technology**

It is difficult to assess both the quantitative and qualitative British contribution to the development of the IAEA safeguards system. In the preceding period, as Simon Rippon noted, the development of procedures and technology for safeguarding nuclear materials was generally neglected in the 1960s and early 1970s.\(^{(71)}\) Whilst this may have been true in the 1950s and early 1960s consideration of these issues was extensive between 1967 and 1971. By 1977 Dr Anderson, formerly of the UKAEA's Nuclear Materials
Accountancy team at Harwell noted that the IAEA system represented an "outstanding achievement in international collaboration in political, legal and technical fields". (72) As an advanced civil nuclear power the British played a leading role in the IAEA discussions between December 1968 and September 1970.

A series of technical meetings were held to consider safeguards procedures and technologies; for example, work was done on reprocessing plants, reactors, fuel fabrication, systems analysis, inspection technology, design information and verification. (73) When the committee to work out the safeguards procedures for the NPT convened in June 1970, it soon became clear that the existing safeguards system based on INFCIRC/66 Rev.2 would have to be revised. The British took the same view. (74) The British then took the lead in establishing an IAEA committee to work out a model safeguards agreement for NPT signatories. Consequently a safeguards committee held its first meeting on 12 June 1970 and completed its work on 10 March, 1971 after 82 meetings. This led to INFCIRC/153 in May 1971. (75)

Some idea of the level of the British contribution can be seen from the IAEA Working Groups, Panels and Consultants Meetings on safeguards. Of the twenty eight such meetings held between April 1970 and June 1976 the British participated in twenty five. (76) There was British representation in the Technical Working Group, 14-18 December 1970, on Instrumental Techniques in Reprocessing Plants, for example, and in a consultants' meeting 22-26 March, 1976 on non-destructive assay techniques. (77)

There was substantial British representation in two IAEA nuclear safeguards technology symposia held in 1978 and 1982, the fourth and fifth of a series which began in 1965; for instance, BNFL, the UKAEA, the Department of Energy, the CEGB and Ministry of Defence. In particular, the
Safeguards Office of the Department of Energy's Atomic Energy Division, which had been established in 1971, and the UKAEA's Nuclear Material Accounting and Control team from Harwell were closely involved. One of the projects included in the UK Safeguards Programme was detailed at the 1982 symposium:

The requirement was to mark permanently the surfaces of the containers with a 'signature' which was not easily forged, even with sophisticated equipment. It was proposed to position the unique 'signature(s)' strategically so that they would be damaged by any attempt to enter, change the contents or to reseal the container. Therefore, on reading the 'signature' the damage would be detected and the auditors alerted to the need to examine the container's contents.(78)

Work was also done at Dounreay on safeguards for fast reactor fuel reprocessing. It was concluded that plutonium in solid and liquid wastes could adequately meet not only safeguards requirements, but also plant control and accountancy criteria.(79) This latter point demonstrates a key point about safeguards technology. Many of the procedures and new monitoring equipment, such as an "enrichment meter" which detects isotopic composition in a gas centrifuge plant, are desirable in their own right for operational reasons. In short, there is no clear separation between safeguards technology and operational requirements for material control.

Both BNFL and the UKAEA undertook contract work on safeguards technology R & D. Identification of "material balance areas" in nuclear plants, fuel cycle facilities such as enrichment for example, are vitally important for safeguards purposes. To this end BNFL's natural uranium fuel fabrication plant at Springfields was used to illustrate the problems that arise in defined Material Balance Areas (MBAs) in such a facility.(80) The Agency's
Safeguards Division placed a R & D contract with the UKAEA Reactor Group in 1977/8 to develop a technique to verify the fissile material of irradiated fuel in a zero power reactor. (81) By 1980 the IAEA noted that the UK had provided valuable assistance in improving the effectiveness of safeguards. (82) Perhaps the most important contribution was made to the pilot programme on remote continual verification. This is a system of sensors directly linked through telecommunications lines to computers in order to establish real time, constantly verifiable safeguards systems. RECOVER was tested at facilities in Australia, Austria, Bulgaria, Canada, FRG, Japan, US and Britain. (83) As with RECOVER the British were by no means the only contributors to IAEA safeguards projects. Other advanced nuclear states, the US, FRG and Canada and the Soviet Union also contributed. The British contribution was, and is, largely a consequence of the long standing British involvement with nuclear power. Experience gained in operating all the key fuel cycle plants and advanced reactors, the fast reactor in particular, inevitably put the British in a position to contribute.

In 1975 the IAEA Director-General established a Standing Advisory Group on Safeguards Implementation (SAGSI) to provide advise on technical aspects of Agency safeguards. SAGSI had its origins in a Japanese proposal of 1971. (84) However, the British were amongst its founder members, SAGSI held its first meeting in December 1975. Although SAGSI is, theoretically, a purely technical, body Fischer argues that its members necessarily try to advance their governments' views and interests. However, generally speaking the British try to avoid its politicisation fearing that the political controversy which has afflicted other UN organisations would devalue and weaken the Agency. This is a measure of the British concern with safeguarding the atom; however, this is not to suggest that the British do not pursue their "technical" arguments to the full. The British maintain a Permanent Mission at the IAEA which
although staffed by FCO personnel, is also supported by the Department of Energy's Safeguards Office. By 1982 SAGSI's main interest was examination of safeguards approaches to the fuel cycle.\(^{(85)}\)

4. Conclusion

It seems reasonable to assume that the British contribution to safeguards technology was at least equal to those of other leading nuclear states. British participation in the IAEA bureaucracy, a permanent seat on the Board of Governors for example, is an inevitable consequence of British involvement in the establishment of the IAEA itself in the mid 1950s. At that time Britain was the world's leading civil nuclear power. Although the British only came to support the concept of full-scope safeguards for non-NPT states in 1975, materials and equipment were always subject to export controls. Consideration was always given to the export of nuclear materials. For instance, very early on in the history of the UKAEA there was a formal directive forbidding the Authority to embark on any undertaking having international implications without referring to the official interdepartmental Committee on Nuclear Energy, and, if need be, through that body to the Cabinet Committee on Atomic Energy.\(^{(86)}\)

As noted in chapters 4, 5 and 6 the British were and remain firmly committed to Atoms for Peace principles. It was always hoped that the British civil nuclear industry could establish a lucrative export trade in reactors and fuels. Although the British, in the early days at least, were prepared to provide these to any state and subsequently to non-NPT states, there is no evidence to suggest that safeguards were not required in some form. The best way to reduce proliferation risks and cultivate a responsible attitude in non-NPT and non-OECD states was by persuasion rather than denial or insistence on unacceptable preconditions. Safeguards cannot be imposed. For this
reason the British were keen to involve non-NPT states in the work of the IAEA Safeguards Division; for instance, Brazilian membership of SAGSI. It was hoped that the NPT and IAEA non-proliferation regime would make nuclear trade both easier and freer.

Although the ethos of Atoms for Peace required the clear separation of civil and military programmes this has not been possible in Britain. The controversy during the Sizewell Inquiry over the end-use of CEGB/SSEB plutonium, and denial of physical access to the reprocessing line was one largely created by historical circumstances. First, the initial secrecy surrounding the military programme was inherited by the civil programme, largely because of the interrelationship between the two. For example, the BEA were excluded from the decision making process which led to the first nuclear power programme in 1955. Britain's fuel cycle plants were built originally for the military programme, but came to have a dual purpose. The 1958-59 MDA further confused the issue since the was little recognition then of the need to maintain a clear separation between civil and military nuclear facilities. The decision to modify some 'civil' Magnox stations to provide military plutonium is indicative of this assumption.

Safeguards in a NWS were originally opposed by both the UKAEA and Ministry of Technology. Since Britain was a NWS, which was subsequently recognised by the NPT and built into the non-proliferation regime, there was no point in wasting IAEA resources in safeguarding fissile material in a NWS. For the British, even though safeguards were accepted, INFCIRC/153 and the NPT are designed primarily to deter through assurance of early detection the diversion of fissile material to military purposes in NNWS. As noted in chapter 3 Britain largely regards proliferation in horizontal rather than vertical terms. Despite this the British have played a key role in developing both the institutional and technical aspects of the IAEA safeguards system. Crucially, the British have assumed, as they did
during INFCE an intermediary role between those states insisting on a restrictive safeguards requirements (US, Canada, Australia), and those who were less enthusiastic (France, FRG, Belgium) and preferred a less rigorous safeguards regime.
CHAPTER 11
BRITAIN AND THE INTERNATIONAL NUCLEAR FUEL CYCLE EVALUATION (INFCE)

1. INTRODUCTION BACKGROUND TO INFCE 1974-1977

Since the launch of the Atoms for Peace Programme in 1953 it had been generally accepted by the nuclear industry, that spent thermal reactor fuel would be reprocessed. The recovered plutonium would then be used for fast reactors. These assumptions were based, primarily, on doubts about the availability of natural uranium ore. Reprocessing and fast reactors offered an ideal solution. Both fuel cycles would make more efficient and economic use of existing resources; moreover, once the fast reactor came into use, complete energy self-sufficiency would be possible.\(^{(1)}\) However, in the mid 1970s two events combined to question the desirability of moving to the "plutonium economy". India's May 1979 nuclear test was the catalyst. Plutonium produced in an ostensibly civil reactor, the CIRUS heavy water reactor, was used for the underground test in Rajasthan. This emphasised the relationship between civil and military nuclear technology.\(^{(2)}\) Although the Indian Government claimed that theirs was a peaceful test, it nonetheless propelled the proliferation issue to the fore front of the international agenda. INFCE was a product of renewed concern over proliferation issues.\(^{(3)}\) Furthermore, as Brenner notes, "the explosion ... blew a psychological hole in the world's confident perception of how difficult it was for a marginally proficient state to build a bomb, and how hard it would be to evade safeguards against surreptitious exploitation of a nominally civilian program."\(^{(4)}\)

India's test contributed to a change in US non-proliferation policy. The Atoms for Peace principles, in which the peaceful uses of nuclear technology were made
available, were called into question first by the Ford Administration. However, it was not until President Carter took office in January 1977 that the transformation was completed. In short, the Carter Administration argued for much tighter control over nuclear technology exports than had previously been the case. The West German/Brazilian deal in 1975, in which Brazil would receive a complete nuclear fuel cycle, and French plans to supply reprocessing plants to Pakistan, South Korea and Taiwan underlined the dangers inherent in the spread of sensitive technology. American anxiety over the implications of these developments led to the Nuclear Non-Proliferation Act of 1978 which tightened up US export controls. Moreover, the US was also a founder member of the Nuclear Suppliers' Group which also tried to improve export controls on sensitive nuclear technology. But the Carter Administration focussed on the back-end of the nuclear fuel cycle and on the fast reactor because both involve large quantities of separated plutonium. To forestall the move to the "plutonium economy" the US deferred its commercial reprocessing and fast reactor programmes in the hope that this self-denying ordinance would induce other states to follow suit. It had the opposite effect.(5) Western European states and Japan maintained that both reprocessing and the fast reactor were fundamental to their nuclear power programmes, and more importantly vital for their short and long term energy security. For resource poor states confronted with unavailability of Middle Eastern oil supplies, nuclear power was regarded as the only practical and readily available alternative. The conflict between the interests of energy security and those of non-proliferation was thus particularly acute. Whether these were compatible or fundamentally irreconcilable was the core issue of the INFCE study. Polarisation of the international community between the United States on the one hand as the world's major supplier of power reactors and toll enrichment, and on the other hand, the West Europeans, Japanese and Group of 77 states, threatened the
stability of both the international non-proliferation regime and the nuclear market.\(^{(6)}\)

At the Heads of Government Summit at Downing Street in May 1977 discussion centred on the problem of reconciling the need for nuclear power with the need to avoid nuclear weapons proliferation.\(^{(7)}\) The United Kingdom Atomic Energy Authority Annual Report for 1976/77 stated that the summit, "recognised that increased reliance will have to be placed on nuclear energy if the world's energy needs are to be satisfied, while avoiding the danger of the spread of nuclear weapons."\(^{(8)}\) However, the seven-nation summit endorsed Carter's proposal of 7 April, 1977 that an International Nuclear Fuel Cycle Evaluation should re-examine the basic assumptions of the plutonium economy.\(^{(9)}\) Carter hoped that "an improved fuel cycle", which would eliminate concern about nuclear weapons proliferation, could be found.\(^{(10)}\) Indeed the Carter Administration hoped that the Evaluation would find in its favour by vindicating the undesirability of reprocessing and fast reactors. But INFCE examined all aspects of the nuclear fuel cycle. Particular emphasis was laid on alternatives to existing fuel cycles which are based on the separation of pure plutonium, and the use of highly enriched uraniu-m - HEU.\(^{(11)}\)

An organising conference for INFCE was held in Washington between 19-21 October, 1977. In addition to the seven states of the Downing Street summit a further thirty-five states and four international organisations participated.\(^{(12)}\) The conference communique outlined INFCE's terms of reference, procedures and methodology. Eight Working Groups were established. These were chaired by states who "volunteered to assume the responsibility."\(^{(13)}\) Although the participants agreed that INFCE was to be a technical and analytical study and not a negotiation, the communique nevertheless referred to specific political matters. In particular, three interrelated statements
highlight the conflict between energy security and non-proliferation.

First, the participants were conscious of the urgent need to meet the world's energy requirements and that nuclear energy for peaceful purposes should be made widely available to that end. Second, they were convinced that effective measures could and should be taken at the national level and through international agreements to minimise the danger of proliferation of nuclear weapons without jeopardizing energy supplies or the development of nuclear energy for peaceful purposes. Finally, it was recognised that special consideration should be given to the specific needs of, and conditions of developing countries. The solutions to these problems, as INFCE implicitly recognised, were political rather than technical. This is the basis of the NPT which itself was a further institutionalisation of the Atoms for Peace and IAEA framework. INFCE ran from October 1977 to February 1980. Throughout this period the British played an important, and indeed crucial part.

2. BRITISH PARTICIPATION: ROLES AND OBJECTIVES 1977-1980

Contributions were made to all eight working groups by British individuals; however, as co-chairman of Working Group 4 (WG4) on Reprocessing, Plutonium Handling, Recycle, the views of the British Delegation, headed by three key individuals: Sir Hermann Bondi, Chief Scientist at the Department of Energy, Cyril Buck from British Nuclear Fuels Limited and Dr Walter Marshall from the UKAEA, are apparent from the final report. The Delegation had back-up support from the Atomic Energy Research Establishment, Harwell; BNFL; the Department of Energy and the Foreign and Commonwealth Office. FCO officials dealt primarily with Working Group 3 on Assurance of long term supply of Technology, Fuel and Heavy Water and Services in the interests of National Needs Consistent with non-
proliferation. Throughout INFCE the Delegation reported directly to the Cabinet Office. (15) The continuity of British attitudes to proliferation is clear from the Delegation's contribution to INFCE's deliberations and final reports. The purpose of this chapter is to illustrate three things: first, the British position at INFCE; second, the relationship between the domestic nuclear programme and British non-proliferation policy; and third, that the position adopted at INFCE is not at odds with Britain's previous approach to the proliferation issue. The only departure was the greater visibility of the British government's and nuclear industry's concern with the proliferation problem.

American reprocessing and fast reactor policy was greeted with dismay in London, Bonn, Paris and Tokyo. Sir John Hill, Chairman of the UKAEA and BNFL, regarded Carter's policy as unsound, a view widely shared in the UK. The Europeans and Japanese shared a common view; reprocessing was an essential part of the nuclear industry. (16) Since the French and Japanese had no indigenous energy supplies, both planned to produce between sixty and seventy percent of their electricity from nuclear power. States from the South, Argentina, India and Pakistan were irritated by yet another example of "technological colonialism". This compounded the indignation arising from the NSG. NNA NPT parties were equally incensed, Yugoslavia and the Philippines especially. These states were not prepared to endorse further safeguards provisions; moreover, Carter's non-proliferation policy in general was attacked as a blatant manifestation of nuclear neo-colonialism. Consequently the international community was divided largely because the NNA perceived the supplier states to be unilaterally altering the norms of nuclear trade. It was for this reason that the British were anxious to involve these states in INFCE, indeed several working groups had NNA chairmen.

Since the reprocessing of Magnox and overseas LWR fuel was
central to British civil nuclear policy, there was a clearly defined commercial interest to defend.(17) Largely for this reason the British and Japanese volunteered to chair the working group on Reprocessing, Plutonium Handling, Recycle. Although US policy was criticised in some quarters on the grounds that it was motivated by technical inferiority and commercial jealousy, the British took the view that this was not the case.(18) Instead US concern with proliferation in general and plutonium in particular was considered genuine; moreover, it did serve as a welcome reminder of the proliferation problem, but the obsession with plutonium was regarded as fundamentally misplaced.

Given the disagreement between the US and other OECD states, and between North and South, the principal objective of British policy was to ensure that INFCE ended harmoniously.(19) In short, there should be no split in the OECD and NATO states and between North and South. The existing conflict was a danger to both non-proliferation and energy security objectives. Indeed it was the very "capriciousness of uranium suppliers which compelled states to opt for reprocessing."(20) An attack on a state's legitimate energy security interests was likely to compel it to build indigenous fuel cycle facilities. Additional enrichment and reprocessing plants are undesirable from the non-proliferation perspective since they produce large quantities of separated fissile material. Construction of such plants did not necessarily mean that their builders intended to take up the weapons option; however, it substantially reduced the barriers and shortened the time scale should such a decision be taken in the future.

Carter's non-proliferation policy focussed on plutonium. However, the British considered this approach totally flawed in several respects. Exclusive concern with the back-end of the fuel cycle ignored awkward technical problems.(21) Technical factors dictated that Magnox fuel
should be reprocessed. Magnox fuel element cladding was not designed for long-term storage, and could not be kept indefinitely in the Windscale and CEGB/SSEB cooling ponds. The then pessimistic forecasts of uranium availability - those of the early and mid 1970s - made a compelling argument for recycling the unused uranium contained in spent thermal reactor fuel. Consequently the once through, or throw-away fuel cycle, was undesirable on technical and economic grounds. Moreover, plutonium was required to fuel fast reactors, which was desirable on energy security grounds. Once fast reactors reach equilibrium, production of a net gain of plutonium, they become self-sustaining, thus obviating the need to depend on imports of scarce uranium. There are also non-proliferation reasons for choosing this fuel cycle, but this will be discussed below.

Fast reactor technology was central to the future of the British civil nuclear power programme. By 1977 fast reactor research and development was the UKAEA principal function. There were, therefore, institutional reasons for opposition to Carter's call to defer the fast reactor option:

The Authority recognise the desirability of the international examination of alternative fuel cycles which was proposed at the London summit meeting in May 1977. They note, however, that the studies of alternative fuel cycles which have been carried out so far suggest that the full utilisation of uranium resources can only be achieved by the exploitation of plutonium fuelled fast reactors. (22)

According to Bondi it was a question of pressure. The resource rich US could afford to halt fast reactor research whereas states like Japan and Britain could ill-afford to abandon fast reactor R & D which they regarded as vital to their long-term energy security. (23) There was no pressure on the US to rely on either reprocessing or the fast
reactor because it possessed indigenous uranium reserves.

Although Britain was comparatively well endowed with energy resources, coal, oil and gas, the potential energy security advantages of the fast reactor were nonetheless regarded as valid for the UK. Increased competition for finite resources and political interferences with energy supplies both at home and abroad confirmed the desirability of increased reliance on nuclear power. This view was further elaborated by Walter Marshall. The industrialised states had a duty to the lesser developed countries to reduce their consumption of oil. This would release supplies for development of LDC economies. Moreover, competition for uranium supplies could be reduced by the advanced states building fast reactors, leaving LDCs to construct thermal reactors. (see chapter 7)

British objections to the US obsession with the back-end of the fuel cycle were based on the recognition that plutonium was not the only fissile material. Protection of the front-end of the fuel cycle, where highly-enriched uranium could be produced, had to be considered. With the advances in enrichment technology, gas centrifuge in particular, U235 was potentially easier than the plutonium 239 route to a bomb. Indeed the British had recognised this in 1962 in a working paper submitted to the ENDC. (ENDC/60 31 August, 1962). Thus the exclusive US focus on plutonium was dangerously blinkered. However, the US let it be known at INFCE that reactor-grade plutonium - plutonium with a fissile fraction of between 50 and 70 per cent - could be made to explode. This information shattered the myth that such plutonium could not be made to explode. Although the other nuclear weapon states present did not challenge this statement, this revelation came as news to the head of the British delegation. (24) The British had tested two devices with a high Pu240 content in 1953. Bondi argued that since fabrication of an uranium weapon is much easier than designing and fabricating an implosion mechanism for
plutonium, he as a government scientist would now advise a non nuclear weapon state to choose U 235 for nuclear weapons rather than Pu 239. Furthermore, a small gas centrifuge plant would be much easier to conceal than a dedicated reactor and associated reprocessing plant necessary for the plutonium route. Indeed Bondi noted that if he were a scientist in a LDC NNWS and was asked to construct a weapon from reactor-grade plutonium, he "would pack up and leave."(25) It was assumed that if a state was going to build nuclear weapons, then it would not choose to divert plutonium from a civil power programme for sound technical, financial and commercial reasons. It would be cheaper to build dedicated facilities to produce weapons-grade material than to interfere with the smooth commercial operation of civil plants.(26) This perspective was shaped, in part, by knowledge derived from Britain's civil and military programmes in the 1950s.(27)

3. WORKING GROUP 4

Since the British co-chaired WG4 attention will be paid primarily to the Group's Main and Summary Reports. However, BNFL and URENCO representatives contributed to Working Group 2 on Enrichment. British officials also participated in Working Group 5 on Fast Breeders and Working Group 6 on Spent Fuel Management. There were contributions to all groups, but these were where most work was done. Although INFCE was a technical and analytical study and not a negotiation, Working Group 3 was "purely political" and as such was dealt with by the FCO.(28) WG4's objectives were:

(a) To evaluate the need for reprocessing of thermal reactor fuel on an industrial scale and for recycling it in thermal and fast reactors, taking account of economic, environmental, energy resource, technological and institutional aspects and of the work of other
relevant working groups.

(b) To identify means of minimising the risk of proliferation in relation to the reprocessing and recycle of nuclear fuels.

Even though the report stressed the interdependence of eight factors, only a few are of immediate relevance to British attitudes to proliferation. Discussion will therefore focus on the safeguards aspects of reprocessing and institutional arrangements. It is also important to note the order of priorities in the WG's terms of reference. It was assumed that nuclear power would continue to be used. The proliferation risk, although important, was insufficient reason to constrain or abandon its use, or further development of nuclear power. Furthermore, INFCE's terms of reference recognised that special consideration should be given to the specific needs and conditions in developing countries. As noted in Chapters 4, 5 and 6 the British had similar priorities. Recognition of the developing countries' needs was no hardship for the British as they had always been prepared to offer such states technical assistance, research and power reactors and relevant fuel cycle services.

WG4's observations and conclusions bear a close resemblance to British thinking on non-proliferation issues. Statements on plutonium re-use for example, are identical to those made by Walter Marshall in the UKAEA's monthly journal Atom. There appears to be a close correlation between British non-proliferation policies and internal nuclear policies; for instance, reprocessing and the fast reactor in particular. In essence the British argued that the interests of their domestic programmes were also in the best interests of non-proliferation. The problem is to decide whether Marshall's arguments in favour of the non-proliferation benefits of the fast reactor were merely convenient after-the-fact rationalisations for a programme
which the British had every intention of pursuing for commercial and energy security reasons. Alternatively, Marshall's arguments may have been a genuine attempt to deal with a particularly sensitive issue and not just a self-serving justification. Plutonium production was a fact of life; therefore, it was not a question of abandoning nuclear power, but managing it so as to reduce the proliferation risks. (33) There is evidence for both interpretations. In 1977 the UKAEA's Annual Report stated prior to INFCE's organising conference:

It is right that an issue of such vital importance to the future of the United Kingdom should be thoroughly and publicly aired. It is however important that the debate should not result in delaying vital decisions to the detriment of the nuclear industry and its position in international trade and deferring the economic benefit to the country from the lower cost electricity generated by nuclear stations. (34)

This suggests that the British thought INFCE should uphold their objections to the US position on plutonium use. A parallel may be drawn with the French role in INFCE. Working Group 2 on Enrichment was co-chaired by France. The French delegation considered its objective to defend national commercial interests in gaseous diffusion as the appropriate technology for EURODIF's assault on the world toll enrichment market. The French were not to be moved from this position: "We have decided and that is right". However, the same charge may be levelled against the British, but their delegation was prepared to adopt a conciliatory line designed to re-build consensus.

WG4's conclusions are identical to the observations aired by Marshall in the Atom articles. These were at the root of the original British objections to the initial US position. Section 6 of the Summary Report identifies the
problem:

It is worth noting that plutonium is inevitably produced when operating nuclear power plants. The problem is therefore not how to avoid such production, but how to manage the plutonium once it has been created. In that respect two main choices can be considered: leaving the plutonium in stored spent fuel elements without reprocessing; and reprocessing of the spent fuel elements followed by storage of separated plutonium or the recycling of the separated plutonium in thermal or fast reactors. (35)

Methods for minimizing the plutonium risk entailed in these options had already been aired by leading British nuclear personnel prior to INFCE. Both institutional and technical means were mentioned by Sir John Hill in the summer of 1977. Practical demonstration of two methods for improving safeguards over plutonium were referred to in the July issue of Nuclear Engineering International. First, centralize plutonium processing to minimize transport of this element. The UKAEA hoped to close the fast reactor fuel cycle by building a small fuel fabrication plant at Dounreay thus obviating the need to move fuel elements between Windscale and Dounreay. Second, mixed oxide fuel elements should be irradiated immediately after fabrication. This increased diversion resistance since it would take much longer to separate the plutonium and manufacture it into a form suitable for use in a nuclear weapon. (36) These options were referred to in paragraph 92 of the Working Group’s summary report.

Although the report argues that proliferation is a political rather than a technical problem, it stresses that the possible connections between nuclear power and nuclear weapons had always been generally recognized. (37) Comparison with British deliberations in the 1950s would bear this out. (38) Despite this the report concluded that,
"any reduction or extension of nuclear power activities gives emphasis to finding ways of improving the resistance to diversion of the sensitive points of all fuel cycles."(39) However, both the British and Americans had declassified material on plutonium and reprocessing in the 1950s without paying sufficient attention to safeguarding reprocessing plants.(40) INFCE, or rather WG4, was the first serious international examination of the proliferation risks of plutonium handling and reprocessing. It was not until 1978 that the IAEA established, with British sponsorship, the International Working Group on Reprocessing Plant Safeguards.(41) The first safeguards inspection of a chemical reprocessing plant was carried out between August and September, 1967.(42) In short, there was very little experience of safeguarding bulk plutonium handling facilities.

WG4 discussed three methods to reduce the proliferation risk: technical measures, safeguards and institutional arrangements. All three were either under active consideration in Britain before INFCE, or were supported at the IAEA in the 1970s. However, although it was argued that technical measures may reduce the risk of theft, they have only a "limited influence in reducing the risk of proliferation", IAEA safeguards were deemed to be much more effective, especially in sensitive areas such as reprocessing and MOX fuel fabrication where plutonium exists in relatively pure form.(43) But WG4 conceded that there was very little experience of safeguards implementation for these two processes. Despite this one of the principal conclusions noted that in the future, "it will be essential to take full account of criteria for effective international safeguards from the inception of plant design together with the resultant cost. The design stage should include an evaluation of the overall safeguards strategies proposed."(44) BNFL plant operators, (Cyril Buck was Director of the Reprocessing Division between 1974 and 1978), were persuaded of the value of
safeguards and that they would not impose unnecessary obstacles in the way of smooth commercial operation. Nor would safeguards permit any IAEA inspector to have access to commercial secrets. Safeguards criteria were taken into account at its design stage of BNFL's planned thermal oxide reprocessing plant (THORP). A British proposal on reprocessing and plutonium safeguards stressed the contribution of containment and surveillance for an effective safeguards system. Both are complementary to material accuracy. Moreover, it was concluded that with these systems a degree of probability of detection greater than 93% could be achieved. (45)

British non-proliferation proposals of the 1970s are broadly consistent with the requirements of the domestic programmes. Nor do they represent a fundamental departure from previous policies. This may be seen from WG4's consideration of Institutional Arrangements. Six different arrangements were considered, some correspond to proposals outlined by the British government and nuclear industry at the Windscale Public Inquiry and at the IAEA. (46) Reference will be made to three of them (1, 4 and 6). Two factors in particular were important in the assessment of these institutional arrangements: non-proliferation resistance and security of supply. (47) This was echoed by BNFL and Department of Energy at the Windscale Inquiry:

Initially it seems likely that if reprocessing is carried out, then the economic incentive to build large-scale plants may mean that it is not necessary for small countries to establish the technology simultaneously, but those countries who did build large national reprocessing plant could offer reprocessing services to countries who are at an earlier stage in their nuclear development. (48)

This view was already a key argument in defence of THORP at the Windscale Inquiry. (49) Non-proliferation objectives
here are closely related to the need for "security of supply". If states can be assured of access to reprocessing, and other fuel cycle services, there is less incentive for them to construct uneconomic plants. Denial of services would be counter-productive. Con Allday, BNFL Managing Director argued:

My personal view that it would have the reverse effect. We have already seen the signs of a tightening up in certain countries as a result of the American policy. I think a redoubling of the determination in Japan, for instance, to proceed as quickly as they can with their own reprocessing plant and to move ahead as quickly as they can with their fast reactor programme and I think this is a result of the American announcement. I think the same is happening in France and is likely to happen in Germany. I think if we were to deny people these services I think it would only redouble their effort and determination to become even more intent than they are now... Their concern is to make sure that they have adequate energy... and can rely on the UK for reprocessing, if they cannot then I do not think it will rebound to our credit.\(^{(50)}\)

Furthermore, Sir John Hill expressed a similar view well before WG4 issued its final report:

If we had a hundred countries with nuclear power programmes and a hundred countries with reprocessing plants it would be all too easy for there to be a rush to nuclear proliferation. The initiative by President Carter was a most important initiative. Having hundreds of reprocessing plants in the world is not the way the world should go if we want to avoid proliferation... The availability of international plants where countries with small nuclear programmes can have their fuel reprocessed is
probably the only way to get worldwide acceptance...(51)

Indeed it does not make commercial sense to build a reprocessing plant when there is only one power reactor in existence. This raises legitimate suspicions on the real purposes of the plant. Pakistan is a clear example.

Sir Hermann Bondi and Cyril Buck argued that the British did have a commercial interest to protect at INFCE, reprocessing of overseas irradiated LWR fuel. Moreover, the British had not only their own energy security to protect, but the security of BNFL's customers. This interrelationship is crucial. It is not sufficiently clear from the public record whether the non-proliferation benefits of centralised reprocessing plants were a convenient after-the-fact rationalisation for a purely commercial enterprise, or a genuine non-proliferation policy. It is probably both since it seems that for the British, commercial interest and non-proliferation objectives are not irreconcilable, but complementary. There are, in short, no absolute positions.

One thing, however, is clear. Throughout the 1970s British governments and the nuclear industry itself were forced to make their stand on proliferation issues more public. Given the unquestioned assumption that nuclear power was vital then it did make sense, for the British at least, for both commercial and energy security reasons for reprocessing to be done in nuclear weapon states such as Britain. Similar arguments were made in relation to the supply of enriched uranium by URENCO.

Multinational or regional nuclear fuel cycle centres under IAEA or other international auspices were proposed and endorsed by the British in the 1970s. The IAEA's study of RNFC, for example, had enthusiastic British support.(52) Moreover, IPS was re-examined as a result of a British initiative. The purpose of such institutional arrangements
is to ensure, "international confidence in the security and reliability of fuel cycle services." (53) It should be noted here that a harmonious resolution of the differences between the US and Western Europe, and between supplier and customer were two key interrelated British policy objectives. Political interference with the supply of toll enrichment and the threat posed to reprocessing by US policy produced considerable instability in the international nuclear market. Such unpredictability threatened the non-proliferation regime. British officials took the view that self-denying ordinances or denial of services was much more likely to increase rather than reduce the proliferation risks. The M/RFCC concept was one possible mechanism to ensure that states had secure access to fuel supplies for their nuclear programmes; for example, multinational involvement would prevent one state from using a monopoly position to impose unacceptable conditions on supply. Dr. Robert Press, Scientific Advisor at the Cabinet Office, argued that US policies between 1946 and 1953 had been counter-productive. Rather than inhibit proliferation, denial had only encouraged it. (54) Consequently security and reliability of fuel cycle services were essential since this would reduce the incentives for independent nuclear programmes. The conclusions reached by WG4 corresponded to those of WG3:

International confidence in the security and reliability of fuel cycle services is essential. This is likely to be enhanced by having several possible sources of supply, giving the customer a choice. Security of supply may also be better assured by multinational or international arrangements, which at the same time offer economic advantages (from economics of scale) and may help to reduce the risk of proliferation. They would also reduce the difficulties caused to both consumers and suppliers by overlapping bilateral controls. (55)
These conclusions correspond to observations made by British officials at WPI and the IAEA. Thus the reprocessing of oxide fuel from overseas customers at Windscale could contribute both to non-proliferation objectives and security of supply. THORP could serve as a base for a multinational or regional fuel cycle centre. Though it is not clear whether this was actually considered. Nevertheless acquisition of overseas business was THORP's principal purpose. Although provision of fuel services for overseas customers had been one of the objectives outlined for British nuclear policy in the mid 1950s, this was the first time that the non-proliferation advantages of this policy were made public. Rather than have an uncontrolled and unsafeguarded expansion of nuclear power with the construction of additional fuel cycle centres, it was better to offer guaranteed supplies of vital fuel supplies to states with demonstrable needs. The special requirements of developing countries was one of INFCE's considerations. WG4's conclusion did not differ from either British views or from the tenor of the main and summary report; for example, "if they decide to reprocess, they would therefore probably find it economic to use the reprocessing services of a large national or multinational plant."(56) LDCs should, in short, make use of THORP.

The similarity between the conclusions of WG4 and British interests and non-proliferation policies should not be surprising. In October 1978 Walter Marshall stated that although he did not anticipate the production of a master plan for non-proliferation, he nonetheless believed that a consensus would emerge, and that it would be consistent with UK policy.(57) The British had no problem in reconciling the ostensibly diverging interests of energy security and non-proliferation. Maintenance of states' energy security interests would also further non-proliferation objectives. This position evolved as a consequence of three interrelated factors: Anglo-American relations, especially between 1946 and 1953; the requirements and objectives of
the domestic nuclear programme; and finally the basic rationale for the British civil programme: nuclear power is necessary in the long term for energy security.

4. WORKING GROUP 3. ASSURANCES OF LONG-TERM SUPPLY OF TECHNOLOGY FUEL AND HEAVY WATER AND SERVICES IN THE INTERESTS OF NATIONAL NEEDS CONSISTENT WITH NON-PROLIFERATION

Although WG3 was co-chaired by Australia, Phillipines and Switzerland, the British contributed to its work. Moreover, as noted above WG4 regarded the "security of supply" of reprocessing and other fuel cycle services as fundamental to any non-proliferation regime. Assurance and security of supply, are the vital interrelated concepts. The fundamental principle, which WG3 refers to in its summary report - assurance of supply, is no different from British policy. Here the regimes created by the IAEA and NPT are crucial:

A right to develop nuclear energy for peaceful purposes, under appropriate safeguards, for economic and social development, consistent with national priorities and needs and with non-proliferation. (58)

This basic principle was supported by the British first during the negotiations which led to the formation of the IAEA in 1957; and later, during the NPT negotiations in the ENDC between 1965 and 1968. Central to both WG3's deliberations and the British position is that "assurance of supply and assurance of non-proliferation are complementary." (59) BNFL's rationale for THORP, referred to above, was echoed by WG3. Without going into detail it is worth reproducing the arguments underlying both positions:

Not only do effective non-proliferation assurances
facilitate supply assurances but non-proliferation commitments of any country may be considered stronger to the extent that such a country relies on international markets for a part of its nuclear supplies. Moreover, greater assurance of supply can also contribute to non-proliferation objectives by reducing the pressures for a world-wide spread of enrichment and reprocessing facilities.\(^{(60)}\)

Because of the long-lead times in the nuclear industry and centrality of nuclear power to states' energy programmes, long term commercial contracts and a "more uniform, consistent and predictable application of national export and import controls" combine to reduce the uncertainty and unpredictability in the nuclear market. The NSG had been subject to bitter criticism from consumer countries precisely because it was perceived as an attempt to deny them the necessary technologies and services for their nuclear programmes. Moreover, NSG represented a form of technological colonialism designed to keep the industrialised states in their privileged position. This did not contribute to the stability of international nuclear trade. It was in order to repair the damage that the British were keen to involve the LDCs in INFCE. Indeed as Boardman and Grieve observe, one British INFCE delegate considered that only stability in the international nuclear market could reduce the incentive for countries to become independent in the fuel cycle, and avert the fear and risk of proliferation that such development entails. There was a need to rebuild confidence that non-proliferation does not mean interference in supply arrangements, and that commercial contracts will be fulfilled subject to non-proliferation conditions.\(^{(61)}\) It should be remembered that the Carter Administration's reluctance to authorise the Japanese to have their spent fuel, which was of US origin, reprocessed threatened to undermine the commercial attractiveness of THORP. Since most of the world's LWR fuel is of US origin, refusal to grant MB10s (approval for
re-transfer and reprocessing) would increase uncertainty for BNFL's long term planning. Therefore the British had ready reasons to support assurance of supply. (62)

WG3's report outlines several proposals to ensure that the interests of supplier and customer are not damaged. To this end adequate non-proliferation assurances and safeguards, as well as mechanisms to ensure that supply of technology, fuel and materials are not subject to either government interference or market instability were considered. (63) The commonality of interest between suppliers and consumers, energy security and non-proliferation was stressed by the British. Sir John Hill noted in the summer of 1979 that INFCE had already "served to underline the need for nations of the world to consult together on the issues of fuel availability, security of energy supply and non-proliferation in the nuclear field." (64) Bondi endorsed this view. Once again the interrelationship of these three factors is seen as the core of the non-proliferation issue.

One of the most significant outcomes of INFCE's 28 month study was the formation of the IAEA's Committee on Assurances of Supply (CAS). This took on board WG3's conclusions. This development had British support. As Boardman and Grieve note assurance of supply was a "core issue" at INFCE, and it was for this reason that British officials regarded CAS "as a main vehicle for serious nuclear policy debate and for the erasing of Third World doubts about the trustworthiness of the nuclear supplying states." (65) CAS was established in Vienna on 26 June, 1980. In 1979 before INFCE had completed its report, Britain declared at the 34th UNGA that:

There was a pressing need for nuclear suppliers and consumer countries to come together to forge a new and reinforced consensus on nuclear technology for the 1980s... matters for discussion included,
improved supply assurances, improved safeguards to direct and prevent the diversion of nuclear materials the management of plutonium under international control and arrangements for spent fuel storage.\(^{(66)}\)

Thus the interests of Britain's domestic nuclear programme in particular BNFL's position as a leading world supplier of fuel cycle services, are also deemed to be in the best interests of non-proliferation. The key assumption is that nuclear power is necessary to meet British, and world energy requirements. Therefore nuclear programmes should not be abandoned or constrained to accommodate non-proliferation objectives. Instead the task is to reduce the proliferation risks by various technical, institutional and political means. CAS in particular is, from the British perspective, the ideal forum since it seeks to maintain the balance between energy security requirements, commercial interests and non-proliferation objectives.

5. CONCLUSION

INFCE did not produce a proliferation resistant fuel cycle. This had been one of Carter's original hopes. It did, however, find in favour of the British position. There had been a re-education of the Americans. In particular the fast reactor was legitimised in the sense that it was no more of a proliferation risk than the 22 other fuel cycles considered, and that it was even necessary on non-proliferation grounds.\(^{(67)}\) Moreover, not only was reprocessing vindicated, the case for the proposed reprocessing plants in Britain and France was actually reinforced on non-proliferation grounds. This was a reversal of Carter's original thesis that reprocessing and the "plutonium economy" in general would increase rather than reduce the proliferation risks. It should be noted that INFCE was not universally approved. The anti-nuclear movement especially was critical of INFCE's findings.\(^{(68)}\)
It was, for some, a foregone conclusion. There is some truth in this. Cyril Buck regarded the Washington Communique as the best summary of INFCE's deliberations: this was released in October 1977 before the final reports were published. It is worth reproducing the relevant section since it forms the basis of current British views on the crucial civil-military relationship. It is also an accurate assessment of Britain's historical approach to the problem. Successive governments and the nuclear industry have maintained that:

It was recognised that a decision by a government to construct nuclear weapons is essentially a political decision motivated by political and national security considerations. But it was not the task of INFCE to discuss these political matters. In this respect, the task of the study was to consider the possibility that the know-how, facilities or materials used in the nuclear fuel cycle might be misused for the purposes of constructing nuclear weapons - although it was recognised that nuclear energy for peaceful purposes is not the only or perhaps even the preferred route to that end - and also to consider whether any technical, or institutional or improved safeguards measures might be introduced to discourage such misuse. (69)

This reflects an ambivalence which has accompanied the development of civil and military nuclear technology since the 1950s. On the one hand civil nuclear power is neither the ideal, nor even practical route to the bomb: on the other, safeguards for civil nuclear fuel cycles have been regarded as not only essential, but also in need of improvement. This approach makes it possible for British governments to see no contradiction between the promotion of nuclear exports and the requirements of a non-proliferation regime. Plutonium 239 was not the only threat even though the British were aware that plutonium
with a high Pu-240 content could explode. Indeed, HEU was considered a much more likely route. However, as with reprocessing it was preferable that enrichment plants should be limited in number provided assured LEU supplies were available. URENCO could serve as a model for a multinational institutional arrangement which could ensure security of supply and fulfil non-proliferation objectives. Secure access to toll enrichment would reduce the incentive for states to construct their own enrichment plants. It should be remembered that one of the original reasons for URENCO's formation in 1970 was to break the monopoly of the USAEC. WG2 noted that by the early 1980s there would be several LEU suppliers. This would ensure supply since:

These additional sources will provide considerable possibility for consumers to protect themselves by diversification if a sufficient variety of commercial terms and conditions is available. Once again it seems that non-proliferation benefits appear as after-the-fact rationalisations for projects which were conceived primarily as commercial enterprises. In short INFCE did not challenge the basis of either British non-proliferation or internal nuclear policy. As British officials had stated during the NPT negotiations, nothing should be allowed to obstruct the development of nuclear power for peaceful purposes, provided safeguards accompanied its use; this did not contradict INFCE's conclusions. Dr. Robert Press, argued that, "INFCE reinforced the need for a restoration of confidence between suppliers and customers in non-proliferation objectives and policies, based on the bargain implicit in articles III and IV of the NPT. This is a major priority." (emphasis added) INFCE addressed itself to ways and means to "minimise" the danger of misuse of fuel cycle facilities without jeopardising energy supplies or the development of nuclear energy for peaceful purposes. These means involved technical measures, improved safeguards and institutional
arrangements."(73) This was more or less the British position before INFCE. At the IAEA the British made contributions to all three areas: support for co-location of facilities, closure of the fast reactor fuel cycle at Dounreay, and active support for international plutonium storage.
CHAPTER 12

EXPORT CONTROLS, INTERNATIONALIZATION OF THE FUEL CYCLE AND ASSURANCE OF SUPPLY 1974-1982

1. BRITAIN AND THE NUCLEAR SUPPLIERS' GROUP (NSG)

(i) ORIGINS

The NSG has its genesis in the early 1970s. Under the chairmanship of a Swiss official, Claude Zangger, a committee of most of the main nuclear suppliers drew up a list of sensitive equipment and components which would require safeguards. The Zangger Committee announced its conclusions in August 1974 and advised the IAEA. These guidelines were described in IAEA information circular INFCIRC/209. However, the work set in train by the Zangger Committee did not end in 1974. A series of events combined to provide the catalyst for a much closer re-examination of the international non-proliferation regime. First, India's nuclear test in May 1974 using plutonium derived from a Canadian supplied research reactor demonstrated the dangers inherent in the civil military nuclear relationship. Second, prospective French and West German contracts to provide enrichment and reprocessing technologies to NNWS in the Third World opened up a vista of additional NWS in sensitive areas of the world. Consequently, on a suggestion of US Secretary of State, Dr. Henry Kissinger, Canada, France, the FRG, Japan, the UK and the US and USSR met in London in autumn 1974 to re-examine ways and means of supplementing IAEA safeguards. Subsequently Belgium, Czechoslovakia, the GDR, Italy, the Netherlands, Poland, Sweden and Switzerland joined the Group which was known as the London Club. For three years these states met in secret and eventually produced guidelines for nuclear transfers on 21 September 1977. This expanded the Zangger Committee's 1974 lists and were incorporated in INFCIRC/254 in January, 1978.
(ii) BRITISH ROLE AND OBJECTIVES

It was no coincidence that the NSG met in London. Although an American initiative, the British assumed a key role in the Group's deliberations.\(^{(4)}\) Moreover, the British did attempt to hold meetings outside London and rotate the chairmanship, but to no avail. As noted in chapters 4, 5, 6 and 10 the British were not only leading suppliers, but took an active part in developing safeguards procedures and technologies. Whereas US policy had oscillated between extremes, Atoms for Peace to tighter controls, and both the French and West Germans had always been wary of safeguards. The British were in an intermediate position.

Throughout the series of NSG meetings the principal British objective was the removal of safeguards from the field of commercial competition. For the British the NSG sought to introduce predictability and to reduce competition between suppliers on safeguards requirements.\(^{(5)}\) A uniform system of safeguards requirements would, theoretically, eliminate the added proliferation risks of states offering nuclear technology and materials under less restrictive safeguards regimes in order to secure contracts. BNFL had lost out to France in South Africa for these very reasons. The British government refused to authorise provision of UF\(_{6}\) conversion equipment.\(^{(6)}\) For this reason the British nuclear industry was keen that there should be a uniform system of safeguards and a clear indication of the "rules of the game". Only then could nuclear trade proceed unhindered; that is, governments would not prevent transactions on the grounds that safeguards provisions were inadequate.\(^{(7)}\) It is clear that BNFL took the same view. In its Annual Report of 1977 it declared that there were an:

increasing number of political constraints which are applied to international nuclear business. These add to the complexity and financial risk of trading in this area. The company wholly accepts that there are
major policy considerations which make some political constraints inevitable, but if the business is to be conducted successfully the necessary political decisions must be taken.\(\text{(8)}\)

French participation in the NSG was considered by the British as a major success in itself. The French till then had excluded themselves from the development of the international non-proliferation regime. In particular, the French had not signed the NPT or participated in its negotiation. As one of BNFL's principal competitors in the international nuclear fuel market French involvement was welcome indeed.\(\text{(9)}\)

By 1975 the NSG had reached provisional agreement on a revised set of guidelines for exports which built upon the Zangger Committee's earlier work.\(\text{(10)}\) However, the main additional factor was the Group's insistence that exports of nuclear technology, in addition to exports of materials and equipment should "trigger" IAEA safeguards.\(\text{(11)}\) Furthermore, the Group also sought to establish a standardised procedure covering re-exports of nuclear materials, equipment and technology.\(\text{(12)}\) Despite this the group was divided. On one side the US tried to insist on denial or at least more restrictive controls. French and West German plans to provide reprocessing and enrichment technologies to Pakistan, South Korea, Taiwan and Brazil caused acute anxiety within the US Administration. Both the French and West Germans, although recognising non-proliferation objectives, were much less enthusiastic about the restrictive policies favoured in Washington. The British took an intermediate role as they were to do in INFCE. Full scope safeguards were the ideal, but in the absence of consensus they should not be made a prior condition of supply.\(\text{(13)}\) In short, although keen that safeguard requirements should not be minimised, the
British do not seem to have endorsed the more restrictive US policy.

Towards the end of 1976 the NSG invited the GDR, Czechoslovakia, Poland, Belgium, Sweden, Italy, the Netherlands and Switzerland to attend the meetings with observer status. This move was designed, presumably, to broaden the base of the NSG by including as many supplier, or potential supplier states as possible. At this stage of the negotiations the Soviet Union proposed that full-scope safeguards should be made a prior condition on all nuclear exports. The British were sympathetic, but given their policy on safeguards announced at the UN in 1976, it seems unlikely that they would have insisted on full-scope safeguards at this time. Despite these differences the revised guidelines were beginning to take shape; for example, controls on enrichment technology included a requirement that it would not be used to design plants, producing uranium beyond 20% U235. Reactor fuel charging and discharging equipment and control rods also appeared on the lists. These were already included in INCIRC/209. However, additional items were also included such as gaseous diffusion barriers, gas centrifuge assemblies resistant to the corrosive UF₆. Part B, common criteria for Technology Transfer, Paragraph 6 of the Guidelines called for safeguards to be "triggered" by the transfer of sensitive technology such as reprocessing, enrichment or heavy water production equipment. In particular:

The transfer of facilities, or their major critical components or related technology, should require an undertaking that IAEA safeguards apply to any facilities of the same type constructed in the recipient country during an agreed period and that there should be in effect at all times an agreement permitting the IAEA to apply its safeguards to facilities identified by the recipient or by the
supplier in consultation with the former as using transferred technology.\(^{(18)}\)

It was not until September 1977 that the full set of guidelines were published. At a NSG meeting chaired by Britain, in September, it was agreed to publish three documents: Guidelines for nuclear transfers; Annex A. Trigger List referred to in Guidelines; and Annex B, Criteria for levels of Physical Protection.\(^{(19)}\)

However, the eventual outcome did not make any mention of full-scope safeguards even though the British had tried throughout the NSG to have them included.\(^{(20)}\) Indeed the US, Canada and Britain tried to include full-scope safeguards in the guidelines only to have this move blocked by other suppliers led by France.\(^{(21)}\)

The Guidelines did not place an embargo on the export of enrichment and reprocessing technology. Despite this David Fischer, Assistant Director in charge of the IAEA's external affairs, noted that INFCIRC/254 brought "a degree of order and consensus among suppliers, to ensure relatively minimum safeguards and uniform interpretation of NPT obligations and to bring France into the 'Club' even though it was not an NPT party."\(^{(22)}\) For the British this was probably an acceptable outcome even though full-scope safeguards were not part of INFCIRC/254. A major British objective in NSG was to establish "the rules of the game" for international nuclear trade. This would ensure that safeguards were removed from commercial competition. However, this would suggest that the British considered the existing NPT safeguards regime as inadequate; however, proliferation problems could be minimised if all states would accept full-scope safeguards which was not the case with the NPT regime. Indeed, in February 1978 a FCO Minister of State noted that, "we have succeeded, with the other 14 members of the NSG, in preparing guidelines which form a minimum agreed standard."\(^{(23)}\)
Moreover, the British were still prepared to provide reprocessing and enrichment services to overseas customers. It was hoped that this would remove the need for such states to build their own plants. Since BNFL is one of the world's only two suppliers of reprocessing services this move is perfectly logical. Indeed whilst the NSG was meeting in London BNFL was negotiating a major reprocessing contract with the Japanese.

Despite accusations by Third World consumers that the NSG was a suppliers' cartel designed to maintain the technological hegemony of the developed world, the British did not regard NSG Guidelines as breach of their commitments under Article IV of the NPT. To the charge that the NSG was a 'secret conclave' Dr. R.I.T. Cromartie argued that the Group's results were published in detail in INFCIRC/254, and in related documents which were circulated to all IAEA member states. Moreover, "it would have been remiss of exporting parties to the NPT not to be sure of their responsibilities to reduce the risk of proliferation as much as possible." Nonetheless the British were not blind to this resentment. It was for this reason that the British sought to involve LDCs in INFCE and CAS in order to restore consensus.

CONCLUSION

It seems clear that the British were sufficiently concerned about the proliferation risks made all too clear by the Indian nuclear test to take a leading role in the NSG. Support for the concept of full-scope safeguards for all states was a significant shift in the British position. However, as noted in Chapter 10 there was no question of coercion. Safeguards could not be imposed; outright denial of either nuclear technology or services was considered counter-productive. Any alteration to the international non-proliferation regime could not be imposed unilaterally.
Major changes in the "rules and norms of international trade required acceptance by all states concerned."(29) A stable and predictable international market with uniform safeguards provisions would not only further non-proliferation objectives, but secure Britain's commercial interests. NSG was part of a strategy designed to achieve this objective.

2. MULTINATIONAL/REGIONAL NUCLEAR FUEL CYCLES CENTRES, INTERNATIONAL PLUTONIUM STORAGE

Although both the Baruch Plan and the IAEA statute envisaged some form of international control over fissile material, it was not until the mid 1970s that interest in internationalization of the fuel cycle revived. Article XII.A.5. of the IAEA statute, for example, sought physical international control of plutonium at the most sensitive stage of the fuel cycle - the storage and handling of plutonium in separated form after reprocessing and before use. An MFCC is basically a limited number of states pooling their resources in a single centre to provide fuel cycle services. This might include contributing funds to capital and regional running costs, joint planning and policy of research and development while each state builds its own plants. A RFCC may combine the above but serve a specific region.(30) Two factors combined to rejuvenate the MFCC/IPS concept. First, the Indian nuclear test of 1974 highlighted the inherent proliferation risks of an ostensibly civil fuel cycle.(31) Second, the worldwide expansion of civil nuclear power generated a demand for enrichment and reprocessing services. The prospect of numerous national facilities, particularly in sensitive regions, was an outcome to be avoided. Such was the view of the Carter Administration. For these reasons internationalization of the fuel cycle presented an attractive alternative. It could further both non-proliferation objectives and contribute to security of supply. This was recognised in the Final Declaration of
The Conference recognizes that regional or multinational nuclear fuel cycle centres may be an advantageous way to satisfy, safely and economically, the needs of initiating or expanding nuclear power programmes, whilst at the same time facilitating physical protection and the application of IAEA safeguards and contributing to the goals of the Treaty. (32)

Three concepts will be considered here, two of which were examined by IAEA Experts Groups: multinational, regional fuel cycle centres and International Plutonium storage. (33)

Dr. Kissinger raised the issue of multinational centres for reprocessing at the NSG. (34) However, there was little initial enthusiasm for the proposal. In particular, the British were, according to Michael Brenner, unhappy with the plan viewing it as a wholly unworkable and perhaps a commercial threat to BNFL's reprocessing business. Nevertheless, the British were subsequently prepared to link their fuel cycle plants with an international non-proliferation regime. This did not involve full internationalisation which would entail access of foreign personnel and agreement to relinquish absolute control over the facilities. (35) Instead the British proposed to offer expanded capacity at the Windscale reprocessing plant to overseas customers. (36) For instance, joint financing of the proposed thermal oxide reprocessing plant from Japan was included in a major contract concluded in 1977. (37)

In 1975 the IAEA commissioned a study of the concept of regional nuclear fuel cycle centres. This was completed in early 1977 and a two volume report was issued in May before the IAEA conference at Salzburg on Nuclear Power and its Fuel Cycle. (38) The Summary Report concluded that a RFCC
offers several advantages in meeting non-proliferation objectives, when compared to the alternative of a further expansion of national capabilities.\(^{39}\) For instance:

The most important of these advantages is that states are offered an incentive to engage in multinational alternatives to national reprocessing and thereby to reduce the number of national facilities constructed.\(^{40}\)

There were also strong economic arguments in favour of a RFCC. Significant savings could be derived from the economies of scale of large-scale operations.\(^{41}\) A similar argument was made by both BNFL and DEN at the Windscale Inquiry.\(^{42}\) In addition safeguards procedures, whilst no different from those which would be applied to national plants, would nevertheless be enhanced since multinational involvement would make illicit diversion much more difficult.\(^{43}\)

In a study of MFCC commissioned by the Department of Energy Ian Smart noted that such a centre would reduce the risk of unrestrained access to separated fissile material, and contribute to improved confidence in assured and guaranteed supplies of fuel and services. This latter point was particularly important because unilateral alterations to, and cancellations of, existing contracts by some supplier states only encouraged the establishment of sensitive fuel cycles facilities.\(^{44}\) MFCC would, in short, promote both international stability and expanded use of nuclear power.\(^{45}\)

URENCO was singled out as a model for a successful M/RFCC. Smart argues that it not only serves the energy motives of economy, education and legitimation but also the non-proliferation motives of deterrence and demonstration.\(^{46}\) The combination of commercial interest, security
and assurance of supply and non-proliferation objectives were the three most important arguments in favour of M/RFCC. BNFL were therefore in the happy position of being able to argue that THORP and URENCO satisfied these criteria in part. For the British commercial interest and non-proliferation objectives became conveniently merged. Although Smart's work did not represent official government policy(47), Dr Cromartie UK Permanent Representative at the IAEA, appeared to consider the report's findings as worthy of further examination.(48)

In spring 1976 the US revived the IPS concept at the IAEA.(49) However, it was not until December 1978 that an expert group was established by the IAEA to examine the IPS concept. Twenty five Agency members participated initially, including the British.(50) In part the study arose because of the Carter Administration's concern that separated plutonium in increasingly large quantities posed a major proliferation risk.

One of the principal British objectives at INFCE was to refocus the non-proliferation debate which had centred on plutonium. Equal attention should be given to the HEU route to the bomb. Moreover, plutonium use was central to British nuclear policy.(51) Consequently the British were leading proponents of IPS because it might provide a realistic balance between non-proliferation objectives and non-interference with national energy programmes.(52) As BNFL already operated a reprocessing plant and planned to build a thermal oxide fuel reprocessing plant, it would be logical to concentrate reprocessing in existing facilities. The recovered plutonium, "should be stored carefully under international supervision."(53)

Once an IPS was established, plutonium would only be released for demonstrably civil purposes. However, the IPS Expert Group, like CAS, was not exempt from the wider North-South conflict. As the study progressed its scope
was curtailed. NNA states tended to regard IPS as yet another suppliers' attempt to maintain their position by denying them advanced technology.\(^{(54)}\) Argentina, for example, was not prepared to subject all its facilities to nuclear safeguards as envisaged by an IPS system. On safeguards in general the Argentinian position is, as Jorge Espil notes, "intimately linked with the freedom of action needed for an independent nuclear programme" aimed at transforming Argentina into a supplier nation. This should not be surprising since independence had been a major factor in both British civil and military programmes. The desirability of closed nuclear fuel cycle is one key reason for the failure to establish MFCC/RFCC.\(^{(55)}\)

The British position on IPS and fuel supplies to non-NPT states can be seen from events following URENCO's decision to provide LEU to Brazil. Although both the FRG and UK had no difficulty with the contract, there were considerable doubts in the Dutch Parliament in early 1978.\(^{(56)}\) The Dutch were concerned with the contract's proliferation implications and tried to insist on more rigorous safeguards procedures. In particular, the Dutch sought to ensure establishment of storage arrangements for recovered plutonium before LEU deliveries commenced.\(^{(57)}\) As the agreement stood IPS arrangements did not have to be agreed by Brazil until the fuel came to be reprocessed.\(^{(58)}\) The Brazilians found the Dutch proposal unacceptable. However, the conflict was resolved at ministerial level (British, Dutch, West German and Brazilian). Any separated plutonium recovered from URENCO supplied uranium would be stored under international control until required for civil purposes.\(^{(59)}\) It was intended that storage would be part of the IPS concept which the IAEA had started to examine in detail. However, should this fail to produce an agreed regime by the time the fuel required reprocessing, ad hoc arrangements would be made. Here the four governments and the IAEA would work out a separate agreement.\(^{(60)}\) Dutch
prevarication irritated both the British and Germans who were keen for the deal to continue. The importance of demonstrating reliability was important here.(61)

For the British IPS represented a potentially useful mechanism to satisfy the commercial interests of BNFL/URENCO, assurance of supply and non-proliferation objectives. It seems that British commercial interests could best be accommodated within an internationally agreed framework of uniform safeguards requirements. IPS was also a useful mechanism to preserve British energy security interests from the attacks on the plutonium economy launched by the Carter Administration. For this reason internationalization of the fuel cycle, whether IPS or MFCC/RFCC, was broadly in line with British non-proliferation objectives, domestic energy security requirements and commercial interests in the international fuel market. The Brazilian/URENCO agreement suggests that such schemes could ensure that enrichment and reprocessing contracts could proceed. Indeed, it was considered that although the fuel could be stored in Brazil, the UK was a much more likely location.(62)

Despite the interest shown in IPS no system was established. Although the outlines of a system were agreed by most of the IAEA Expert Group, nothing materialised. The Expert Group appeared to favour an IPS regime being administered by a commission elected from IPS members. The commission, whose functions would include setting policies and procedures as well as budgets, would not have control over plutonium release. Instead control would be exercised by IAEA officers, the Board of Governors and if necessary independent arbitrators.(63) According to Fischer the Group was divided into three: the opponents, Argentina, Yugoslavia, India and Pakistan: the middle group, FRG, Japan and Italy, and those in favour, Australia, Canada, Netherlands, Sweden, UK and US.(64) In short, there
was no consensus on the IAEA Board of Governors.\(65\)

Perhaps the principal reason for this failure was the lack of pressing commercial demand.\(66\) Indeed by the late 1970s and early 1980s the economics of reprocessing, the excess capacity in the enrichment sector, earlier predictions of the expansion of civil nuclear power failed to materialise, and decline in immediate concern with proliferation combined to deprive IPS and M/RFCC of a sense of urgency. Lack of commercial demand for such services appears to have been crucial. As Fischer notes, "Governments do not invest large sums of money simply to promote non-proliferation."\(67\)

CONCLUSION

Nothing in the British position over IPS, M/RFCC is inconsistent with British non-proliferation policies as manifested in CAS, NSG and at the NPTRCs. As noted in previous chapters there is a fundamental interrelationship between on the one hand internal British nuclear energy policies and commercial interests as a leading supplier of fuel cycle services; and on the other non-proliferation policy. The latter emphasised the need for adequate and uniform safeguards coupled with guaranteed and assured supplies of nuclear material equipment and components. In the climate of the 1975-1980 period both IPS and M/RFCC appeared to be a useful medium through which to pursue these interrelated objectives.

3. COMMITTEE ON ASSURANCES OF SUPPLY

In the wake of President Carter's non-proliferation policy, which was based on a much tighter control of nuclear trade, the advantages of assurance of supply became particularly attractive. This was understood to entail provision of nuclear fuel and reactor components. Although the 1978 US Nuclear Non-Proliferation Act emphasised the desirability of assurance of supply, the Act and the NSG guidelines
were perceived by customer states as an obstruction placed in the way of their legitimate energy programmes.(68) Moreover, the 1974 US decision to cease provision of enrichment services and the Carter Administration's opposition to reprocessing combined to destabilise the international nuclear market. Unpredictability was at the root of the problem. States could not be sure that contracts for supplies of nuclear fuel or technology would be fulfilled. For this reason as noted in the chapter on INFCE, assurance and security of supply were recognised as a key requirement for a mutually acceptable non-proliferation policy. The British saw particular advantage in the development of mechanisms to ensure continuity of supply. Enrichment and reprocessing services were central here. British interest was made clear at the 1980 NPTRC.(69) At the 34th United Nations General Assembly First Committee the British took the view that the IAEA was the most logical forum in which to pursue this issue.(70) Furthermore, the British argued that there was an urgent need for suppliers and consumers to re-establish a consensus on nuclear trade for the 1980s. In particular, improved supply assurances and safeguards should be two matters for discussion.(71)

As first conceived at INFCE assurance of supply required some mechanism that guaranteed assurance of supply, fuel services and reactor components for example, in exchange for strong non-proliferation commitments.(72) Initially the US was not enthused by such a proposal, but conceded that some movement in this direction was necessary. Amongst the NNA the Philippines took the lead in trying to establish within the IAEA, "a powerful committee on supply assurances."(73) Indeed the Philippines made much of the nuclear suppliers' unreliability at the 1980 NPTRC once CAS had been established.(74) Uncertainty surrounding nuclear supplies threatened the integrity of not only the Filipino nuclear power programme, but also those of other LDCs. Mexico was particularly vocal on this issue.(75) However,
during the internal deliberations within the IAEA the British were opposed to any committee with as widespread powers as those prepared by the Philippines.\(76\)

The reasons for British opposition are not readily apparent; however, since the Philippines sought to establish a committee with review functions over IAEA Expert Groups, on International Plutonium Storage in particular, it is plausible to assume that this constitutional change in IAEA procedures was the source of British opposition. Moreover, as noted in Section 2 the British were active IPS supporters. It seems that the British sought to keep the IAEA's expert committees confined to 'technical' studies. The politicisation which would ensue from such a change would devalue the technical groups' utility.\(77\) Any alteration to an established system which appeared to work well may have been an additional factor here. It appears that the British favoured establishment of an advisory group which would have a "different constitutional function from a Committee of the Board". This Group would report through the Director General rather than to the Board of Governors.\(78\) This would be a more efficient way to look at supply assurance.\(79\)

Despite British opposition to the organizational form, rather than the principles of assurance of supply several weeks of intense negotiations led to a "qualified victory" by the LDCs. In June 1980 the IAEA Board of Governors approved the establishment of the Committee on Assurances of Supply; however, the original review power over current IAEA expert groups was dropped. Instead the Committee was confined to advising the Board of ways and means to assure nuclear supplies, "on a more predictable and long-term basis in accordance with mutually acceptable considerations of non-proliferation; and the IAEA's role and responsibilities in relation to those objectives."\(80\) The Committee was open to all IAEA member states.\(81\) The
CAS would further repair the damaged relationships between suppliers and customers; a process which had been set in train at INFCE. This seems very clear from the public statements. (82)

Membership of the Committee was divided into three groups corresponding to political allegiances: the Western Group, the Socialist Group and the Neutral and Non-Aligned Group. Chairmanship was rotated annually so that a representative of each group would chair the Committee once every three years. Its first Chairman was a Yugoslav. (83) Of its four officers, a chairman and three vice chairmen, two would always be drawn from the NNA. Many NNA member states participated in the first meetings, regarded CAS as an opportunity to ensure individual supplier states were prevented from breaking contracts unilaterally. (84)

Once CAS was established the British largely endorsed its objectives. These were broadly similar to the UK civil industry's interests. BNFL's position as a leading supplier of fuel cycle services could be developed to further assurance of supply and non-proliferation objectives. This had been explicit in both the Company's and Government's case as early as the Windscale Public Inquiry. (85) Creation of an international regime in which British nuclear exports could prosper without adding to the proliferation risks had been a major aim of British non-proliferation policy since the 1960s. CAS was consistent with this objective. At the 1981 IAEA General Conference the British representative was confident that CAS, "would greatly assist in the development of improved arrangements which would permit nuclear trade to flow more freely under reliable and equitable non-proliferation objectives." (86) Ian Smart, a British diplomat in Washington during the NPT negotiations has noted that this was one of the Treaty's principal objectives. (87)
In November 1981 CAS established two Working Groups. One covered Principles of International co-operation in the field of nuclear energy in accordance with the mandate of CAS; the second discussed emergency back-up mechanisms of fuel and component supplies.\(^{(88)}\) Despite this the committee found it difficult to establish and maintain a consensus.\(^{(89)}\) As the IAEA Annual Report noted, assurances of supply and safeguards requirements were not just a contentious issue between North and South, but also within industrialised states.\(^{(90)}\) Indeed when CAS was established in 1980 Nucleonics Week reported the reaction of "several sources" thus: (it) will be a committee of complaints. All of the discussions which took place on Articles 3-4 of the NPT are going to continue... Up to now we have been faced with the NPT reviews every five years... this new committee will be a kind of permanent review of the functioning of the treaty.\(^{(91)}\) Nevertheless British officials regarded CAS as the main forum for easing NNA doubts about supplier states reliability.\(^{(92)}\) As the British knew from experience, unpredictable, unreliable and unreasonable suppliers only encouraged independent nuclear programmes which increased proliferation risks.

CONCLUSION

The British role in CAS cannot be viewed in isolation from other non-proliferation initiatives and nuclear fora in the 1970s; for example, INFCE, NSG, IPS, RFCC, MFCC, NPTRCs and the Windscale Public Inquiry. There is a similarity in the positions assumed and objectives pursued at all of these events. Furthermore, defence of British commercial interests was equated with non-proliferation objectives; that is, desirable non-proliferation criteria such as supplier predictability, assured supplies of nuclear material and fuel, are also in BNFL's interest. Since nuclear power was perceived to be vital for British energy security it followed that this also viewpoint obtained for
LDCs. There could be, therefore, no question of prohibiting nuclear trade. By the early 1980s the British considered CAS to be the best fora in which to pursue the dual objectives of security of supply and non-proliferation. This would involve participation of all states not just NPT members. The best way to involve NNWS outside the NPT, such as Brazil and India, was to encourage them to take a constructive role in developing the international non-proliferation regime. Refusal to provide nuclear fuel, or exclusion from the IAEA would, in the British view, only encourage such states to become more hostile to the NPT and full-scope safeguards. In contrast, CAS provided a constructive medium through which to strengthen the international non-proliferation regime. This appears to be the basis of British participation in CAS.
CHAPTER 13

CONCLUSION

During sessions of the Committee on Assurances of Supply (CAS) in 1981 the British IAEA delegation believed that as a first step:

The Committee could encourage the development of more uniform, predictable and consistent nuclear trading arrangements by drawing up a set of "guidelines" for the conduct of international nuclear trade that would be acceptable both to the consumers and to suppliers, although the acceptance of such guidelines should not require any party to the negotiation of any future agreement or arrangement to impose or submit to any particular condition.\(^{(1)}\)

This statement accurately reflects both the assumptions underlying British attitudes to nuclear proliferation and the objectives of British non-proliferation and commercial policies. These attitudes and policies have been shaped primarily by three interrelated factors: the rationales for, and objectives of, the domestic civil and military nuclear programmes, and the experiences derived from these programmes. Chapter 3 noted that proliferation was in practice defined in "horizontal terms" by successive governments. The "independent deterrent" was thus not relevant to any consideration of the proliferation problem. Moreover, British possession of nuclear weapons did not affect the calculations or security decisions of other NNWS. Consequently, British non-proliferation policy has largely focussed on the use of, and control of, civil nuclear technology. Despite the relationship between civil and military nuclear technology, no British government has considered it necessary to obstruct or prevent in principle the export of nuclear equipment and materials.
Well before the launch of the First Nuclear Power Programme in 1955, it was hoped that British industry would be in a position to export nuclear reactors, equipment and materials. Indeed this was one of the principal reasons for the 1955 programme. Since then export considerations have played a major part in the formulation of British civil nuclear policy; for instance, they were prominent during debates over thermal reactor choice in the 1960s and 1970s. Although power reactor exports were unsuccessful, a lucrative trade in fuels and reactor components was established. At no time since 1952 have British governments opposed the principle of nuclear exports on non-proliferation grounds. However, it seems that much greater attention, publicly at least, was devoted to the proliferation problem by both Governments and the nuclear industry in the 1970s; indeed, it was not until the 1980s that a separate department devoted entirely to nuclear issues, Nuclear Energy Department, was created in the FCO. However, even in the 1950s British governments required assurances that British nuclear exports were not used for military purposes. Indeed the British argued in the 1960s and 1970s that an adequate safeguards system would make international nuclear trade easier because this would assure suppliers that their exports were not used to further military purposes.

Despite this there does not appear to be any publicly available evidence which indicates that the long-term proliferation implications of promoting and encouraging the spread of nuclear technology were really considered by Ministers or officials in the 1950s. Indeed Lord Penney, who retired from the UKAEA as Chairman in 1967, recollects that most of the anxieties and work on proliferation happened after then. But it is clear that the civil-military relationship was perfectly understood by both officials and Ministers, or at the very least they were aware of it. Indeed the British knew from experiments in Australia that plutonium contaminated with PU.240, such as
that produced in a power reactor, could be made to explode. Furthermore, they even contemplated using "civil" plutonium for nuclear weapons if there was a shortfall in military production. At this time there appears to have been no recognition of the need to maintain the separation of civil and military nuclear programmes for non-proliferation reasons. Britain's status as a nuclear weapon state was at the root of this. Since proliferation was perceived in "horizontal" rather than "vertical" terms, there was no need to maintain an artificial separability in the domestic programmes. For this reason Britain's position as a nuclear weapon state, which is enshrined in the NPT, has been a significant factor in the shaping of British attitudes to proliferation.

The historical context of the 1955 nuclear power programme is significant. Against a background of potential energy shortages occasioned by a struggling coal industry, the attractions of enhanced energy security which could be provided by nuclear power were irresistible. Nuclear power was considered not only necessary, but vital, for British energy security and economic development. This standpoint has remained remarkably resilient over the years precisely because greater energy security has remained attractive to successive governments. In turn it was assumed that this was also likely to be the case for other countries, especially in the developing world. Consequently any acceptable non-proliferation regime should, in the British perspective, (see chapters 8, 11, 12) "maintain a right to develop nuclear energy for peaceful purposes, under appropriate safeguards, for economic and social development, consistent with non-proliferation."(2) Such a regime would ensure not only British commercial interests, defence of the fuel services business, but further non-proliferation objectives. In short, there is no contradiction between commercial imperatives and security requirements; on the contrary, they are, in British thinking, mutually reinforcing. This explains the British
CAS proposal calling for uniform, predictable and consistent nuclear trading arrangements. These conditions are desirable for both supplier and customer. Assurances of supply and assurances of non-proliferation, provided by safeguards, are complementary.

This perception appears to be founded on the recognition that non-proliferation policies based on "technology denial", or which in practice interfere with and threaten states' energy policies are inherently contradictory. In the British case US policies in the immediate post-war period and again in the 1960s and 1970s were instrumental in encouraging independent nuclear programmes. Sir John Hill, one of the leading figures in the British civil programme observes that:

> Almost inevitably, if a country is refused access to the use of technology on reasonable terms then it will feel itself impelled to obtain what has been refused by means of indigenous development. We have seen this after the war, where the exclusion of Canada from the UK/US accords on the protection of nuclear information led to the decision by the Canadians to develop their own reactor which we know as CANDU. We have seen this in other fields as well. As I have said, I feel certain that if the Western World were to persist in a refusal to provide reprocessing services to the less developed countries, then this could have only one effect; that these countries would perforce attempt to develop their own reprocessing technology.\(^3\)

We have seen that the most proliferation sensitive parts of the nuclear fuel cycle are enrichment and reprocessing where huge quantities of separated weapons-grade fissile material can be produced. For this reason the British considered it important to reduce the incentives for non-nuclear weapon states to build their own indigenous plants.
Interference with the supply of essential services for national nuclear programmes, which US policy in the 1970s threatened, or rather was perceived to threaten, would in the British view only compel such states to build their own fuel cycle facilities. The pursuit of independent nuclear programmes outside the framework of the international non-proliferation regime was considered a potential danger to that regime. Consequently such an outcome should be prevented. Even though there was no immediate risk of weapons proliferation from such an outcome, it was better that enrichment and reprocessing should be done in as few states as possible, preferably the NWS. However, the NWS would have to provide assured supplies of fuel services to reassure potential and actual customers. Elimination, or at least reduction, of uncertainty and unpredictability would enhance confidence in the stability of the international nuclear trading system and the non-proliferation regime. Assurances of supply were thus in the interests of both supplier and customer; for example, it provided a stable framework for long-term planning. The British were thus in the happy position of being able to argue that existing export policy, which would have been pursued anyway for sound commercial reasons, was also in the best interests of non-proliferation. Hill noted, for example, that provision of adequate energy supplies to all nations around the world would be of especial importance in assisting us to fight proliferation.\(^4\) Civil nuclear technology would, of course provide the adequate energy supplies. Energy insecurity rather than provision of nuclear materials and equipment was more likely to increase the proliferation risks.

British perceptions and understanding of the proliferation issue have been decisively shaped by the experiences and
lessons of the 1950s. The British military programme itself suggested that any medium industrially advanced state could produce nuclear weapons if a political decision to do so was taken. Thus the existence of a civil nuclear programme does not necessarily give rise to a military programme. However, the Chiefs of Staff noted in January 1946 that Britain was in no way committed to the manufacture of atomic bombs by beginning the construction of two piles. The decision whether to devote their output to industrial development or to bombs could await the actual production of fissile material in the fifth year after pile construction had started.\(^{(5)}\) It would be cheaper and more practical to build dedicated facilities than to divert clandestinely material from a civil to a military programme. However, the British public position on this issue is disingenuous since, as noted in chapters 2 and 3, British governments were prepared to use the civil programme for military purposes in extremis even though it was recognised that this would undermine the commercial operation and economics of civil nuclear power.

It is clear that the British have made a major contribution to the spread of civil nuclear technology whilst simultaneously professing an interest in non-proliferation objectives. Nonetheless the British have played a leading role in the evolution of the international non-proliferation regime. This has enabled the British to play an intermediate moderating role between the exponents of two extremes of non-proliferation strategy: excessive and rigorous control variously advanced by the US, Canada and Australia, and the less interventionist commercial approach of France, the FRG and Belgium. Equally important, the British have tried to restore the consensus in international trade between North and South. This approach can be seen during the NSG, INFCE and CAS proceedings in the 1970s and 1980s.
Perhaps the best short summary of British attitudes to nuclear proliferation 1952-1982 appeared, not surprisingly, in an issue of the UKAEA's monthly bulletin almost at the close of the period in question:

So the aim of non-proliferation and the problem of technological and energy development are at the heart of the political implications of international nuclear affairs. Contrary to appearances these aims are not opposed. Since man has never moved backwards in the field of science, the development of weapons will not be prevented if the countries which have now mastered nuclear energy, stop or limit its civil development. On the contrary, the feeling of frustration and deprivation of energy which would result for the excluded countries could only push them towards developing programmes with military objectives themselves.\(^6\)

In other words there is no contradiction between the spread of civil nuclear power, and the need to prevent the spread of nuclear weapons to other states. As their own experience in the 1940s and 1950s demonstrated, the British knew that if an industrially advanced state was determined to produce nuclear weapons nothing could be done to prevent it. Instead the British thought it more practical, and a more realisable objective, to create an international non-proliferation regime. Five interrelated objectives were all thought to be significant. First was the creation of an international norm against the spread of nuclear weapons. The second was the need to enhance energy security by greater use of nuclear power. The third was the need to enhance energy security by maintaining predictable and stable supplies of nuclear fuels, equipment and information. The fourth was the need to ensure that ostensibly civil materials were not used for military purposes, and to this end it was thought desirable to limit fuel cycle plants in number consistent with the need to
ensure secure fuel supplies for civil programmes. However, these objectives were not allowed to compromise a fifth: British commercial interests, specifically provision of fuel cycle services to overseas customers. British attitudes to nuclear proliferation, as manifested in these five interrelated goals, have been decisively shaped by the objectives of, rationales for, and experiences of Britain's own civil and military nuclear programmes since 1945. It is hoped that this thesis has shown that the confluence of these five particular interests in the recent British position cannot properly be understood without reference to Britain's own nuclear history.
CHAPTER 1


(2) For the purposes of this study proliferation is understood as the spread of nuclear weapons to non-nuclear states - horizontal proliferation. The quantitative and qualitative spread of nuclear weapons within the existing weapons states is described as vertical proliferation. Nuclear weapon states are those which have a demonstrated capability before 1 January 1967.

(3) Gowing Vol. 1. op.cit. p.6.


(9) Interview


(11) Interview


(14) In a letter to the author Fred Mulley, Minister of State FCO with special responsibility for arms control in the 1960s, doubted "if he could add significantly to what can be learned from published documents". He declined to be interviewed about the British role in the NPT negotiations.


(16) Interview. Hinton thought that plutonium produced in CEGB/SSEB Magnox reactors was used for military purposes despite statements made by the CEGB at the Sizewell B Public Inquiry to the contrary. In addition to his leading role in early British nuclear programme. Hinton was the first chairman of the CEGB.

(17) Since 1952 nuclear energy has been the responsibility of six government departments: Ministry of Supply, Ministry of Science, Ministry for Education and Science, Ministry of Technology, Department of Trade and Industry, and Department of Energy where it has resided since 1974.


(20) Williams, op.cit. p.312 But of course this was not the case... There were inevitably rivalries and schisms of greater or lesser moment within the
Authority, between the different groups, especially the Research and Reactor Groups, between the geographically very separated sites, and between different technical philosophies.

(21) FO 371 GE/12/83 President Eisenhower's Proposals for an IAEA. Comments on various considerations affecting the UK's Participation in the scheme. 10 June, 1954.

(22) see Chapter 2.

(23) Simpson op.cit. p.6.


(26) Patterson, op.cit. p.3.

(27) Garthoff op.cit. p.3.

(28) Butcher, op.cit.


(33) Interviews


(35) cited in Williams op.cit. Preface.

(37) op. cit. p.5.


(42) op. cit. pp.11-2.

(43) op. cit. p.13.


(46) ibid.

(47) Mason op.cit. pp7-8


(49) Energy and National Security. Proceedings of a Special Conference ed. T.J. Goldstein, Virginia,

CHAPTER 2


(2) This view is particularly prevalent among anti-nuclear writers. See Walter Patterson, The Plutonium Business and the Spread of the Bomb, Wildwood House, London, 1984. In 1966 Leonard Beaton wrote, "What amounted to the spread of plutonium capacity was spectacularly launched by President Eisenhower in his 'Atoms for Peace' proposals of 8 December, 1953, and the efforts which have followed must stand as some of the most inexplicable political fantasies, only a social psychoanalyst could hope to explain why the possessors of the most terrible weapons in history should have sought to spread the necessary industry to produce them in the belief that they could make the world safe". Must the Bomb Spread? Pelican, Harmondsworth, 1966, p.88.

(3) Gowing Vol. 2 op.cit. p.290.


(5) ibid.

(6) Sir Roger Makins, Nuclear Energy in 1962, Atom, April 1962, p.66. He also noted that the military programme, and the industrial effort which underlay it, gave immense assistance to the development of the civil power programme. Nuclear Energy: A Year of Promise, Atom August 1962, p.196.

(7) AB7/3233. A Summary of Non-Standard Metal Irradiations In The Windscale Piles. J.L. Phillips, 2 April, 1954. Magnox cans were irradiated in Pile 2 in March, 1954 for example p.2 (vi)

(8) ABI6/1330 Windscale Collaboration with BEA on Training for Operation with Windscale Reactors (PIPPA) F.C. How (MOS) to E.J.S. Clark, Paymaster General's Office, 15 April, 1953.

(9) ABI6/1330 12 May, 1953.

(10) ABI6/1330 11 May, 1953. Confidential Notes on a Parliamentary Question re PIPPA. Gowing notes Vol. 2 p.291, that the military specifications eased the engineering problems because the irradiation periods for the fuel rods would be much lower for military plutonium... There were also technical disadvantages from the power point of view, notably the lower temperature necessary for plutonium and the need to
charge and discharge the rods frequently for plutonium production.

(11) ABI6/1330.


(13) Sizewell 'B' Public Inquiry Transcripts Day 277 Tuesday 16 October 1984 p.30c.

(14) C.C. (54) 90 p.3.

(15) ABI6/1475 The Production of Power from Nuclear Energy (Trend Report) p. 3 para 1. It also noted: "The original version of this report contained a small amount of material which was of military significance. This material has been deleted without affecting the argument or conclusions of the report."


(17) ABI6/1475 see also p.47 para 134.

(18) In its conclusion the Trend Report noted that, "in view of the important part played by the costs of processing nuclear materials in the total costs of electricity, effort should be directed towards reducing these as rapidly as possible." Summary of Conclusions p.5 (f).


(20) op. cit. para. 5.

(21) see Chapter 3.


(23) op. cit. col. 793, Sir Ian Horobin.


(25) Sir W. Ackers and Sir J. Woods were the other two committee members.


(27) ABI6/1745 p.10, para. 25 see also memo from Viscount Waverley to Duncan Sandys, Minister of Supply, 26 June 1953,
(28) ABI6/1745.

(29) CAB 128/26 10 August item 9.

(30) op. cit. p.86.

(31) ibid.

(32) op. cit. p.88 Interestingly enough it was also noted that this was true of other weapons; for example, aircraft and tanks where development would have been far less satisfactory if it had been carried out in isolation from corporate civilian work.


(34) ABI6/1745.

(35) op. cit.

(36) see Atomic Energy Act 1954; Interview.

(37) Simpson op.cit. p.277.


(39) op. cit. p.131.

(40) op. cit. p.159.


(42) ibid.

(43) ABI6/1075 16 March, 1953. Letter, F.C. How, Under-Secretary, Atomic Energy Division, MOS.

(44) CAB 131/12 D.52. 29 April, 1952.

(45) CAB 131/12 D.52 4th Meeting 30 April, 1952.

(46) CAB 131/12 D.52. 17 2 May, 1952.

(47) CAB 129/65 C (54) 7.

(48) ibid.

(49) ibid.

(50) ibid.

(51) ibid.

(52) CAB 128/27 C.C. 54.

(53) C (54) 7.

(54) Gowing, Vol. 1 op. cit. p.149.
Gowing Vol. 2, op. cit. p.289. The Chief Scientist at the Ministry of Fuel and Power voiced general feelings... "Even if these power stations do not fit in with our particular pattern, we should acquire a know-how which we could sell to others. We must not leave all export of these commodities to the US" Gowing Vol. 2 op. cit. p.288. The reactor in question was PIPPA, which eventually became Calder Hall.

C.C. (54), 90 21 December, 1954, p.3.

C. 52. 5 November, 1952.

ABI6/1475 p.10 para. 10.

op. cit. p.55 para 171.

C (54) 168, 18 May, 1954.

ibid. The Chancellor was at one with the Minister of Fuel and Power as to the seriousness of the situation. C.54 170 20 May, 1954.


op. cit. p.10 para. 6.

CEGB/P/1 CEGB Policy, J.W. Baker, November, 1982.


op. cit. p.64.

CHAPTER 3


(3) Vertical proliferation is the quantitative and qualitative increase in the nuclear stockpiles of the nuclear weapon states, whereas horizontal proliferation is the spread of nuclear weapons to states who, as at 1 January 1967, do not possess them.


(5) Gowing op. cit. p. 185

(6) Pierre op. cit. p.74


(8) See Gowing Vol. 1


(10) Gowing op. cit. p. 448

(11) S. Connor and A. Thomas, How Britain Kept Its Independent Deterrent, New Scientist, 17 January, 1985 p.4

(12) AB16/1075 Waverley Committee Papers (Internal Memos, Committee, Foreign Office, Ministry of Supply) Letter from R E France to Sir D Parrott, 8 October, 1953.


(14) AB16/391 Minister of Supply to Prime Minister, 7 May 1947.

(15) AB16/391 Plans for the Production Piles p.4 para 29.

(16) Gowing, Vol. 2 op. cit. p. 389

(17) John Simpson, The Independent Nuclear State. The United States, Britain and the Military Atom,
Fuel rods were irradiated between 265 MWD/t and 664 MWD/t.

(19) CAB 131/12 Minutes of Cabinet Defence Committee D.(52). 4th meeting, 30 April 1952.

(20) Simpson, op. cit. p. 252


(22) Gowing Vol. 2 op. cit. p. 401


(27) Freedman op. cit. p. 79.


(29) CAB 131/12 D(52)51. 6 December, 1952.

(30) Memo by Chancellor 5 November, 1952.

(31) C.52.320 3 October, 1952 Defence and Economic Policy Memo by Chancellor of the Exchequer.

(32) D.52.26 Defence Policy and Global Strategy para 140.

(33) CAB 13/12 D.52.41. Cabinet Defence Committee, The Defence Programme Report by the Chiefs of Staff, p.2 para 5.
(34) ibid.


(36) CAB 129/71


(38) DEFE 4 53 Defence Policy and Global Strategy C.O.S. 52. 98th Meeting held on Tuesday 8 July 1952.


(40) Ball, Summer 1983 p. 33.

(41) DEFE 4/53 COS(52) 99th Meeting 9 July 1952.


(43) CAB 131/13 COS D(53)5 29 January, 1953 p. 3 para 5.

(44) op. cit. p. 12

(45) CAB 131/13 D(53)45 1 October p 3 para 10.

(46) Rosenberg 1981/2 op.cit. p.27

(47) CAB 129/71 C(54)329 Defence Policy. Note by the Prime Minister, 3 November 1954.

(48) op. cit. pp 108-9

(49) CAB 128/27 C.C(54)73 5 November 1954 p. 4

(51) Paul Brown, Churchill 'Kept A-Test Secret', The Guardian, 11 January 1985 p. 1, see also Gowing Vol. 1 p. 437 re 1951 Defence Research Policy Sub-Committee on the Military Aspects of Atomic Energy. "This considered what uses there were for atomic weapons other than blasting and bombing cities... tactical weapons to be used against troops and artillery had to be considered as well as strategic weapons".

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(53) Jackson op. cit. p. 22.


(55) op. cit. p. 79.

(56) Steven Meyer, Soviet Theatre Nuclear Forces Part II Capabilities and Implications, Adelphi Papers No.188 p. 4.

(57) Leonard Beaton and John Maddox, The Spread of Nuclear Weapons, Chatto and Windus for the Institute for Strategic Studies, 1962 p. 73, see also Brookes op.cit. p. 72.

(58) Jackson op. cit. p.20.

(59) Brookes op. cit. p.72.

(60) Philip J.R. Moyes, Bomber Squadrons of the RAF and
Their Aircraft, MacDonald and Jane's London, 1976.

(61) Jackson, op. cit. pp 80-81


(63) Jackson op. cit. pp 33-4


(66) Jackson, op. cit. pp 69-70.

(67) Units = kg

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(69) ibid

(70) UKAEA, Tenth Annual Report 1963-4, p.3 para 16.

(71) Thermonuclear Tests. The exact yields remain classified.
range
11 Sept. 58 Pennart 2 Christmas Island GrappleZ
range
23 Sept. 58 Burgee 2 Christmas Island GrappleZ
range
Simpson op.cit. pp.244-5, Hubbard op.cit. p.125

(72) see discussion above of Operation Hurricane. The US General Advisory Committee on 7 November, discussed advanced chemical explosives technology. It noted that, "gains to be obtained from success in this direction are enormous both in reduction in size of large fission weapons and even more importantly in the possibility of making smaller fission weapons of simple design and great economy of fissionable material. It is well known that both the Russians and British are very expert in the field of chemical explosions. It is conceivable to us that they may have made significant advances in this field".


(74) Lowry op. cit. p 6


(76) Royal Commission op. cit. p 387 8.3

(77) New Statesman, 15 February, 1985

The object was also to test techniques to enable the UK to produce smaller megaton weapons...other objectives to explore low yield weapons of light weight using plutonium... study new principles opening routes to cheaper high yield light weight warheads for ballistic rockets. ibid.

(79) The object was also to test techniques to enable the


(81) ibid.
(82) op.cit. p 7.
(83) op.cit. p 6.
(85) AB/480 Isotopes Radio and Stable Production in Production Pile
(86) CAB 128/27 op.cit. p 7.
(87) CAB 128/27 C.C. (54)48 July 1984 item 2 para (3).
(88) op.cit. para (b). The Trident and Chevaline decisions were taken by Cabinet Sub-Committees.
(89) ibid.
(90) ibid.
(91) C.C. (54)52 Confidential Annex 23 July 1954.
(93) ibid.
(94) New Scientist, 8 August, 1957
(101) The Guardian, 17 March, 1983 p. 21. Indeed the first three tests were so successful a fourth was

(102) Simpson op.cit. p 245.


(106) New Scientist, 4 June 1959.

(107) Blue Steel was ordered at an estimated cost of £12.5 million; however, by 1960 the cost had risen to 60 million. The Economist, 5 January, 1963 p 18. In its operational form the Blue Steel ASM was 35ft long with a wing span of 13 feet. Its range was 100 nautical miles and could be launched from either high or low level. It was capable of a maximum speed of Mach 1.6 and carried a thermonuclear warhead with a yield of about 1 megaton. Jackson op.cit. pp 94-5.

(108) Jackson op.cit. pp 94-5.

(109) Taylor op. cit.

(110) The cancellation of the British Blue Streak project forced the British to depend on the US for a delivery system. Blue Streak was a liquid fuelled IRBM which was a planned complement to the V-Bombers. It was cancelled before it was deployed. It was considered too vulnerable to a Soviet pre-emptive attack; for instance, Blue Streak would have taken between ten and fifteen minutes to prepare for launching yet the anticipated warning time was 4 minutes. John Baylis, Anglo-American Defence Relations 1939-1980. The Special Relationship. MacMillan Press Ltd, London, 1981 pp 67-8.

(111) Skybolt was a two stage solid fuel missile with a maximum speed of Mach 5 and a range of up to 1130 miles. It was thirty eight feet in length which meant that it had to be carried on external wing-mounted pylons of Vulcan and Victor B2s. Jackson, 1981 op.cit. p 47, p 51.

(113) Campbell, 1984 op. cit. p 105.


(115) Four Resolution class submarines were built at Vickers Barrow, and Cammell Laird Birkenhead. HMS Resolution was laid down on 26 February 1964 and set out on its first patrol in June 1968. The fourth submarine, originally there were to have been five, was not commissioned until December 1969. The Labour government, elected in 1964, cancelled the fifth submarine; however, as Hilary and Steven Rose noted: "The Labour leaders who had scornfully rejected Lord Hume's meanderings with the firm statement that the independent deterrent was neither independent nor a deterrent were, on translation to office, to be found launching Polaris submarines with all the accoutrements of Church, champagne and sub-Churchillian rhetoric that, out of office, they had scorned". Science and Society, Pelican, Harmondsworth, 1977 pp. 95-6.

The Polaris A-3 missile itself had two stages and has a throw-weight of 1000 lbs capable of carrying three 200 kt thermonuclear warheads; therefore, each warhead could not weigh any more than about 300 lbs. The missile has a range of 2500 nautical miles, and although the warheads were not independently targetable, they did spread out shot-gun style up to ten miles apart: the CEP was 800 metres. Ian Smart, British Foreign Policy to 1985. The Future of the British Nuclear Deterrent: Technical, Economic and Strategic Issues. The Royal Institute of International Affairs, Chatham House, London, 1977 pp 41-2 see also SIPRI, The Arms Race and Arms Control, Taylor and Francis, London 1982, p 144.


(117) Simpson 1983 op.cit pp 254-5 estimates the current size of the British stockpile at 577 of which 238 are controlled by the Royal Navy and Royal Air Force. This is the smallest published estimate of the British nuclear stockpile. cf Gallacher which puts the figure between 1557 and 1947 and D. Campbell, New Statesman 17 April, 1981, p 11 which has a figure of 1402. However, since Simpson's book "Created Waves" at the MOD when it was published the smaller figure of about 600 would seem probable. Simpson puts the number of weapons in 1960 at 120 whereas in 1970 this had expanded to 411, p. 254. The Aviation Studies Atlantic, January 1982 estimate puts the number at 187 in 1960 and 460 in 1970. Either way there was a substantial quantitative and qualitative increase during the decade.


(123) ibid.


(125) Statement on the Defence Estimates 1984 p. 24 para 402. This line was maintained even though The Observer reported that Chevaline had 2 MIRVs. This was based on a US document entitled US Military Posture Fiscal Year 1984. "Polaris Punch to be Doubled", Peter Pringle, The Observer, Sunday 30 October 1983 p 1.


(130) British Nuclear Fuels Limited, Sixth Annual Report 1976/77. p see also Robin Cook, Buy a New Bomb the Easy Way. New Statesman, January 1979 p 42. Rob Edwards and Shelia Durie regarded this development, "as the most important development at Chapelcross since the 1950s". Fuelling the Nuclear Arms Race. The Links Between Nuclear Power and Nuclear Weapons, Pluto Press, London 1982 p 36.
(131) Arkin et al op. cit. p 145.


(133) ibid.


CHAPTER 4

(1) see chapter 3.

(2) Air cooled reactors were easier to build than watercooled reactors. The need for pure water for cooling, and safety requirements combined to produce only one possible site in Britain at Arisaig in the Western Highlands. The remoteness precluded this option. The plutonium route to the bomb was cheaper and easier since production of HEU in a gaseous diffusion plant was expensive and complex. When resources were scarce and electricity expensive such an option did not attract much favour.

(3) Margaret Gowing, Britain Atomic Energy 1939-1945, MacMillan, London, 1964 p.433. Gowing emphasises that this was an important part of British thinking p.79.


(8) ABI6/1475 The Production of Power from Nuclear Energy Trend Report, October 1954. The working party involved the Treasury, AEO, Ministry of Fuel and Power, Reactor and Industrial Groups of the UKAEA. The material referred to was "deleted without affecting the argument or conclusions of the report." It should also be noted the report was based on a Risley Report. Risley was the base of the UKAEA's Industrial Group. Interview

(9) ABI6/1475 para. 186 Exports p 60.

(10) ABI6/1475 para. 192 p 69.

(11) C. (54) 395 Memo by Lord President of the Council p 2 (i).

(12) A Programme of Nuclear Power, Cmd 9389, HMSO,
In 1958 Japan asked the IAEA to arrange for the supply of fuel for a small research reactor, thus triggering the first application of IAEA safeguards. It became necessary to negotiate a detailed agreement with Japan on the basis of the broadly worded provisions of the IAEA statute. It was clear for future arrangements that it would be better to have a set of rules. But it was not until January 1961 that the Board of Governors was able to approve a system of safeguards to cover reactors up to a capacity of 100 MW(th). David Fischer and Paul Szasz, Safeguarding the Atom. A Critical Appraisal ed. Jozef Goldblat, SIPRI, Taylor and Francis, London, 1985 p 23.
Proposals Submission of the AE(0)C Working Party's

Paper to Ministers and Communication to the US
Government. President Eisenhower's proposal for the
Peaceful Development of Atomic Energy para. 3-4.


(27) op.cit. p 5 para 15 "para. 15 is of a top secret
nature and should not be discussed with the US
Government" President Eisenhower's Proposal for the
Peaceful Development of Atomic Energy GER/G27 para.
2.

(28) FO 371 110692 op. cit. Minute Eden to PM, PM/54/8 20
January 1954.

(29) Nuclear Energy Company Ltd. (NEC); Nuclear Power
Plant Company Ltd (NPCC); Atomic Power Group; Atomic
Energy Group; Atomic Power Constructions Ltd. Roger
Williams, The Nuclear Power Decisions British

(30) United Kingdom Atomic Energy Authority, (UKAEA) Third
206.

(31) A memo by the Atomic Energy Board of 12 May 1953,
noted, "In view of the "military" function of the
Calder Hall plant, the fact that BEA will have no
interest in plutonium production, the experimental
nature of the power plant, and the fact that from
BEA's point of view the project is educational", the
Ministry of Supply must design, build and own the
plant and retain broad control of its method of
operation: ABI6/1330 Windscale Collaboration with
BEA, On Training for Operation with Windscale
Reactors (PIPPA).

(32) Irwin Bupp and Jean Claude Derian, Lightwater How the
Dream Dissolved, Basic Books, Inc. Publishers New
York, 1978, p 21

(33) Donnelly op. cit. p114 see note 100. Indeed US fears
that British subsidies would undercut American
exports were echoed, only in the opposite direction,
in the UK: "We cannot see how the Americans are able
to quote as low a price as £90 per kw for a PWR
plant. It may be that they are being subsidised but
if they are there is nothing we can do about it".
AB19/043 Hinton to Claude Gibb (C.A. Parsons Co.
Ltd.).

(34) The contract was reported to be in excess of £10m
Nuclear Engineering, October, 1958 p 417 see also The
(35) UKAEA, Ninth Annual Report 1962-63, HMSO, London p.1 para. 2. Springfields was one of the fuel cycle plants established initially for the weapons programme. In 1958 it was still supplying fuel elements for the Calder Hall and Chapelcross plutonium/power reactors.

(36) The reactor was rated at 150 MW (e). UKAEA, Ninth Annual Report op. cit. p 1 para.2 see also R.F. Pocock, Nuclear Power its Development in the UK. Unwin Bros. Ltd., and the Institution of Nuclear Engineers, the Gresham Press, Old Woking, Surrey, 1977, Appendix B p 232. An early example of 'tertiary proliferation' can be seen from the Latina project. In Autumn 1958 Italy and Brazil concluded a co-operative agreement on exchange of information and experience in nuclear energy. Brazil was to send students and technicians to work on the Latina project. Nuclear Engineering, November, 1958 p.470. However, representatives from the UKAEA's Reactor Group had been in Brazil in March 1956 to hear more about Brazilian nuclear power plans and to assess the extent to which their achievement might be the subject of collaboration between the UK and Brazil.


(38) IAEA, Annual Report 1 July, 1974 - 30 June, 1975 GC (XIX) 544, Vienna, p 45. The agreement is covered by INFCIRC/125.

(39) Sir Edwin Plowden, chairman UKAEA, Sir J. Cockcroft UKAEA Board Member for Scientific Research, Sir Christopher Hinton, UKAEA Board Member for Engineering and Production; William Strath, UKAEA Board Member for External Relations and Commercial Policy; J. Jukes, UKAEA Economic Advisor; Donald Peirson, UKAEA Secretary; A. Balfour, Lord Chandos, AEI; M.H. West, Metro-Vickers; H. Railing, GEC; A. Lindley, H. Nelson, English-Electric; M. Mathews, C. Gibb, C.A. Parsons; J. Wrightson, Head-Wrightson.

(40) AB 19/043 Export of Reactors Overseas Sales Policy.


(42) AB 19/043 C. Gibb (C.A. Parsons Ltd.) to Plowden 29 August 1955.

(43) AB 19/043 Record of Meeting 9 November 1955.

(44) AB 19/043. UKAEA, F.J. Fairly to J.A. Dixon,
Industrial Group. In December, 1953 it was reported that Libya was not going ahead with a reactor purchase.

(45) AB19/043 Memo from W. Strath to E. Plowdon. 2 November 1953.

(46) see also Nuclear Engineering, September, 1958 p 371
E.M. Price, The Overseas Demand for Nuclear Plant. The first country to which economic power makes a special appeal are those whose other natural power resources are limited... supplies too unreliable.

(47) AB19/043. English Electric to E. Plowden. 5 September, 1955 Nuclear Engineering however, noted that "it would be most unfortunate if this opportunity of enhancing the prestige of British engineering was allowed to pass simply because Western Europe was not regarded as our traditional export market." April, 1956 p 2

(48) Interview.

(49) see FO 37110692, The Civil Service Yearbook 1968, HMSO London.

(50) Nuclear Engineering, February, 1961 p 48


(54) AB19/043 Jukes 1956 para. 2.


(56) AB19/043 Gillams, 6. The UK Design Position.

(57) Nuclear Engineering, July, 1956 p 139


(59) UKAEA, Sixth Annual Report 1959-1960, HMSO, London,
p.48 para. 271. This material was subject to assurances of peaceful uses. see Agreement Between the Government of the United Kingdom of Great Britain and Northern Ireland and the Government of the Italian Republic for the Co-operation in Peaceful Uses of Atomic Energy, Cmnd 349, 1957.

(60) UKAEA, Eleventh Annual Report 1964-1965, HMSO, London, p.9 para. 46. In fact the initial agreement had made provision for this; for example, Article VI provided for "fuel of such quantity for and quality as may be necessary for the efficient and continuous operation of research and power reactors" see note 59.

(61) AB19/043 Export of Reactors. statement of Policy Governing Overseas Fuel Sales. Approved by the Authority under AEA (57) 22 Appendix I para. 10 see also Nuclear Engineering, September, 1958, p.368.

(62) AB19/043 memo to Hinton, March 1957.

(63) AB19/043 25 March, 1957.

(64) Nuclear Engineering, April 1958 p.138 appeared to endorse Hill's sentiments. Referring to Eurochemic, "it is quite likely that this lukewarm attitude on our part will cost the UK chemical engineering industry millions of pounds in exports as it is the intention to build over the years a great number of medium-scale fuel processing plants throughout Europe". However, when Eurochemic closed down, a European joint reprocessing concern at Mol, Belgium the UKAEA's Production Group were not sorry to see it go. Interview.


(66) Springfield's annual production of fuel elements in 1962 amounted to 670 tons of which 300 were for Latina, Nuclear Engineering, March 1963, p.99.

(67) In early 1964 the Production Group signed a contract with Aktiebolaget Atomenergie of Sweden for supply of up to 40 tonnes of 1-2% enriched uranium dioxide for making fuel elements for the Marviken nuclear power station. The deal was reported as being worth over £1 million Nuclear Engineering, March, 1964 p.84. 5-7kgs of plutonium were also supplied to Sweden for the second charge of the Agesta reactor at a "favourable price". The proliferation implications can be seen from what the Swedes allegedly used this, or other plutonium for. It was alleged in April 1985 that a weapons research programme continued 18 years after the Swedish Parliament had voted against it. An article by Christer Larsson in Ny Teknik states that underground tests involving small amounts of weapons-grade plutonium imported from Britain and

The first fuel for Tokai Mura, 19 tons was dispatched on 4 May, 1964. It was worth £10 million. Nuclear Engineering, June 1964 p.194.

(68) UKAEA, Eleventh Annual Report op.cit. p.3 para. 14 see also Nuclear Engineering, June, 1968 p.188.


(71) In December, 1964 Nuclear Engineering reported the UKAEA's decision to supply a second load of 45kgs of plutonium oxide to Euratom in March/April 1965. The contract was worth about £750,000 p.442. In addition, the UKAEA provided enriched uranium for irradiation trials in the reactors owned by Electricite de France (Edf) UKAEA, Ninth Annual Report p.44 para.238.


(73) Interviews.

(74) France made the decision to develop a national enrichment capability only after several attempts at international collaboration failed. Work started on Pierrelatte in 1960; it began operation in 1964 and was completed in 1967. Allan Krass, Peter Boskma, Beolle Elzon, Wim A. Smitt, Uranium Enrichment and Nuclear Weapon Proliferation, SIPRI, Taylor and Francis, London, 1983 p.28.


(77) UKAEA Eleventh Annual Report p.14 para. 69. The first movement of irradiated fuel for reprocessing internationally had taken place in 1958 when elements from a French EL2 reactor were sent to Windscale. Nuclear Engineering, February, 1966 p.17. However, a "significant step has been take towards the integration of the UKAEA reprocessing plants into the European nuclear system by the recent successful transportation of irradiated fuel from the Danish research reactor at Riso to Dounreay via Copenhagen and Leith." Nuclear Engineering, November 1962 p.440. Between 1954 and 1965 the UKAEA agreed to
provide nuclear fuel for several states, primarily European. For example, experimental plutonium fuel was made for the Agesta reactor in Sweden. This was for a joint experiment between the UKAEA and ASEA on the use of plutonium as a fuel for thermal reactors, and BR-3 reactor in Belgium. Eleventh Annual Report p.12 para. 57. An offer was made to supply fuel in conjunction with the Magnox reactor tender submitted by a British consortium for the Nuclenor project in Spain op. cit. p.14 para. 73. Fuel was supplied to the Apsara reactor in India and reprocessing offered for the same reactor ibid. p.14. para. 14.


(79) Interview. A leading participant notes that "salesmen were sent out to the US, Japan and FRG and told 'go out and sell and don't come back until you do'." According to New Scientist 18 February, 1965 p.415 Dr. J.M. Hill, then head of the Production Group, represented a more commercial approach which had the backing of the Minister of Technology, Frank Cousins. The basis of this approach as noted above was established in the late 1950s.

(80) UKAEA, Sixth Annual Report 1959-60, p.8 para. 53.


(83) Roger Williams op. cit. p.133; Sir George Thomson argued that: "it is well known that the willingness of the US to supply cheaply enriched fuel has been an important force in selling US reactors abroad... we might perhaps follow the US lead and provide cheap 235 for British reactors". New Scientist, 8 November, 1962. Toll enrichment services were offered to Canada, Spain and Sweden. Nuclear Engineering, June 1963 p.189. The UKAEA, however, charged prices 2 to 3 times higher than the US. The sheer scale of the US enrichment effort placed the UKAEA in a very weak position indeed. It was not until the 1970s that the US monopoly of the world toll enrichment market was effectively challenged by the Europeans.


(85) Nuclear Engineering, December 1959, p.466.

(86) Nuclear Energy No. 6, 1981 p.433. It should also be noted that one of the key Indian scientists who
supervised the Indian nuclear test in 1974, Dr. Raja Ramanna was a physicist trained at London University, Shyam Bhatia, India's Nuclear Bomb, Vikas Publishing House Pvt Ltd., Sahibabad, 1979, p.139.


(90) op. cit. p.32.


(93) The Apsara reactor has a power rating of 400kw (th) and its fuel is 80% HEU. Jozef Goldblat ed. Non-Proliferation The Why and the Wherefore, SIPRI, Taylor and Francis, London, 1985, p.303.


(96) For example, an agreement for the co-operation on Peaceful Uses of Atomic Energy... Switzerland, Cmnd 2487 was signed 11 August, 1964 UKAEA, Eleventh Annual Report 1964-65, p.77, para. 399. The agreement made provision for the supply of research or power reactors, or components and associated fuel; a representative of the Authority's Reactor Group went to Brazil to hear about plans for a nuclear power programme, and to assess the extent to which their achievement might be the subject of collaboration between the UK and Brazil, UKAEA, Tenth Annual Report 1963-64, p.64 para. 35; advice on nuclear energy activities - Turkey op. cit. p.66 para. 344. Advice was given to Pakistan on a new laboratory constructed for the Institute of Nuclear Science and Technology Rawalpindi, UKAEA, Ninth Annual Report 1962-1963, HMSO, London, 1961 para 344 (iii).

(97) Dragon Project signatories were Austria, Denmark, Norway, Sweden, Switzerland, UKAEA and EURATOM. The experiment ran from 1959 to 1976.

(98) E.N. Shaw, Europe's Nuclear Power Experiment. The History of the OECD Dragon Project. Pergamon Press,
The HTR, however, was not a mainstream AEA reactor. Much greater levels of resources were allocated to AGR and (Demonstration) DFR R & D. William Penney notes, "Among all the longer term possibilities for land based thermal nuclear power stations Cockcroft had begun to favour a high temperature helium cooled converter type of reactor using dispersed fuel. The Industrial Group in the shorter term favoured the AGR... The AEA did not have sufficient resources to design and build the AGR and also design and build an experimental HTGCR. Cockcroft spoke informally to a number of atomic energy leaders in Europe and enlisted their support for a collaboration scheme at Winfrith". Journal of the British Nuclear Energy Society, October, 1968, pp.299-300. First Cockcroft Memorial Lecture, Lord Penney.


The NEA was supported by Britain as a counter-project to make atomic integration of the six (Euratom) less attractive. Donnelly op. cit. p. 91. The US was concerned with nuclear competition from the UK since Britain had begun a large scale nuclear power programme well before the US appeared to be a formidable competitor on the world nuclear reactor market. US financial support for the ENEA could have been seen as fostering a competitive British nuclear technology while US financial support for Euratom enjoyed the advantage of being earmarked for projects explicitly beneficial to US nuclear technology. Donnelly op. cit. p.114.


(102) UN. Vol. 16 op. cit. p.39.


(104) Peirson op. cit. p.653.

(105) Sir John Hill, The Scope and Limitations of

(106) Peirson op. cit. p.653. However, the reference to the safeguards system and technology above should be borne in mind here.

(107) UKAEA, Ninth Annual Report 1962-63, HMSO, London, p.58 para. 352. In January 1964 the British Nuclear Forum was established. Its principal objective was to assist in co-ordinating the activities of organisations concerned with nuclear energy in Britain. Besides being an information channel BNF sought to, "publicise British industry overseas and help to organise the nation's participation in international conferences and exhibitions. New Scientist 9 January, 1964, p.87."
CHAPTER 5


(2) JBNES, Vol. 5, No. 1 January 1966, p.5.


(7) Williams op.cit, p.113.

(8) ibid.


(10) Atom No. 117, July, 1966, p.159


(14) Interview, UKAEA 1966-7 op.cit.

(15) op.cit. p.29 para. 132.


For instance, the strategy for Euratom outlined by the "Three Wise Men" recommended Europe to adopt the LWR as the basis of its reactor programme. It has been argued that this decision influenced even if it did not wholly determine the fate of British gas-graphite reactors. Irwin Bupp, Jean-Claude Derian, Lightwater: How The Dream Dissolved, Basic Books Inc. Publishers, New York, 1978, p.48.

The Joint US and Euratom Agreement of November 1958 and the R & D programmes entailed heavy subsidisation of US interests in Europe. This agreement was described as "the brain-child of US participants and reflected American interests more than European ones". It was for this reason that the French were vigorously opposed to US influence. Nau. op.cit. p.127.


(20) JBNES, Vol. 5. No. 4 October, 1966 p.473.


(22) JBNES, Vol. 5, No. 2 April 1966 p.129.

(23) UKAEA, Twelfth Annual Report p.13, para. 63.


(26) NEI, August, 1983 Supplement p.15.


(28) see 16 above.

(29) op.cit. p.xxxv para. 105.

(30) op.cit. p.xiii para. 140. Attempts were made to sell reactors to Austria and Denmark, UKAEA, Thirteenth Report p.83 paras. 429-432.

(31) op.cit. p.xxix para 82.

(32) see note 31.


(34) It is plausible to argue that the NPT, and Article IV in particular, was designed to institutionalise and
regulate international nuclear trade. This appears to have been a major British objective. See Chapter 8.


(38) NEI, August, 1983 Supplement pp.18-9. It should be noted that the subsequently the AGRs proved very reliable indeed. Hunterston B-1 had a 77.9% load factor in 1982, Operating Experience with Nuclear Power Stations in Member States in 1982, IAEA, Vienna, 1984, p.425.

(39) New Scientist, 6 June 1968, p.525.

(40) JBNES, Vol. 7 No. 4 October, 1968 p.270. Benn also said that, "we badly need a successful sales effort abroad which could do more to support the activities of the engineers and the industry than any action that the Government itself can take. The emphasis must now shift to exploitation, particularly in the field of exports - where the record has been disappointing - if we are to reap the harvest which should result from the endeavours of those engaged in the Authority since the war".


(42) JBNES, Vol. 8 No. 4 October, 1968 pp.243-4.


(47) NEI, Vol. 15 No. 166 March, 1970 p.167. Other tenders for LWRs were submitted by Brown Boveri, KWU and ASEA. In the end Austria's first reactor at Tullnerfield near Vienna was ordered in 1971 when KWU won an order for a BWR. Construction started in 1972. However, the reactor was never opened on account of the anti-nuclear vote in the referendum of November 1978. The Economist, 11 November, 1978 p.54.

Efforts were made by TNPG and BNDC to supply Austria with its first nuclear power station, 2500 MWe SGHWR. NEI Vol. 15 No. 166 March, 1970 p.169. Nature 1 March, 1969, p.791.


UKAEA, Fifteenth Annual Report, pp.2-3 para. 10.

In Spring 1968 the BNX had discussions with electrical utilities in Slovenia and Croatia, Yugoslavia for supply of a 500 MWe SGHWR. The UKAEA was in the process of negotiating a similar deal for Romania. NE, Vol. 13 No. 143 June 1968 p.473.


JBNES, Vol. 8, No. 3 July 1969 p.103.

New Scientist, 8 May 1969. It was noted that, "What is most important now is to capitalise on the interest created by the deal to win a new series of orders for British nuclear power overseas".

Walker and Lonnroth op.cit. p.11 and p.25.

see Chapter 2.


NEI, Vo. 13 No. 147 August 1968 p.625. 70 tonnes of nuclear grade graphite, 2 tonnes of U 308 and 450 grams of 80% U235 were also supplied to Romania. UKAEA, Fourteenth Annual Report p.83 para. 413.


UKAEA, Fifteenth Annual Report p.3 para.11.
Herald was used to study neutron physics and for radiochemical and nuclear materials tests. UKAEA, Eighth Annual Report p.77 para. 380.


Select Committee op.cit. p.xvi para. 123.


The Times, 31 December, 1968.

UKAEA, Thirteenth Annual Report, p.18 85a, b. Prior to this the Authority provided 400 tonnes in 1961 and 80 in 1965. NE Vol. 10 No. 11 August, 1965 p.283.

UKAEA, Twelfth Annual Report, p.3 para 64.

NE, Vol 10 No. 106 March 1965, p.86 Promotional activities were initiated in Europe and North America to obtain oxide fuel reprocessing business. UKAEA, Thirteenth Annual Report, p.19 para. 88.

Enriched plutonium fuel pins for the Garigliano reactor in Italy; hire of plutonium to CEEN; hire of plutonium-uranium fuel elements to CEA, France; depleted uranium to Canada. UKAEA, Thirteenth Annual Report, p.18; 300 MTR fuel plates for Jen-1 reactor, Spain, UKAEA, Twelfth Annual Report, p.14. Fuel from Denmark DR-2 MTR was reprocessed at Dounreay. NE, Vol 10 No. 109 June 1965 p.208. A plutonium fuel assembly was provided for the 15MW BWR at Kahl, FRG. NE, Vol. 11, No. 116, January 1966 p.23.

(85) ibid.

(86) Interview


(88) ibid.


(90) UKAEA, Seventeenth Annual Report, p.5 para. 21 In 1968/9 fuel services earned £1.9m, and 4.4 million in 1968/70,


(93) Concentrates are dissolved in nitric acid and the resulting uranyl nitrate solution is filtered. The filtrate passes through a solvent extraction plant where the remaining impurities are removed by selectively extracting the uranyl nitrate into tri-butyli phosphate, kerosene mixture and subsequently washing back into the water. This solvent extraction process enables BNFL to prescribe a relaxed specification for the concentrates accepted for conversion. The pure uranyl nitrate solution is then concentrated in a multi-stage evaporator and the hot concentrated solution sprayed into a heated fluidised bed denitration unit, where it is decomposed by hot air to produce uranium trioxide (UO$_3$). UO$_3$ is then reduced by hydrogen to uranium dioxide (UO$_2$) in a second fluidised bed unit and the UO$_2$ is converted to uranium tetrafluoride (UF$_4$) by reaction with hydrogen fluoride gas. UF$_6$ is finally made by reacting UF$_4$ with fluorine gas in a highly efficient fluidised bed. British Nuclear Fuels Limited, Fuel Manufacturing Services, Risley 1981, p.3.


(94) UKAEA, Seventeenth Annual Report p.19 para. 75.


(97) UKAEA, Fifteenth Annual Report p.19 para. 95b. See also Sixteenth Annual Report, p. 20 para. 91. In the summer of 1969 a reprocessing contract for 28 tonnes of spent oxide fuel from the Zorita power
station, Spain to Windscale was concluded. The fuel was to be delivered between 1971-1975. The UKAEA would buy the recovered plutonium, but it was considered likely that the plutonium would be resold to Spain at a later date. NEI, Vol. 14 No.162 August 1969 p.615. The first consignment of irradiated fuel from the 150 MWe Garigliano BWR was reprocessed at Windscale. This was the first international movement of irradiated fuel from a BWR. The consignment contained 3.88te of Uranium Oxide fuel elements. NEI Vol. 14 No. 16 April 1969 p.312. The recovered plutonium and uranium were returned to Italy.

(98) NEI, Vol. 14 No. 162 August 1969 p.608. In the same year 180 kgs of plutonium were supplied to Belgonucleare. UKAEA, Fifteenth Annual Report, p.19 para. 96 In 1968 8 kgs of plutonium were lent to Sweden. Other services on offer included the provision of space in the Dounreay Fast Reactor for irradiation experiments for overseas customers. In May 1971 more than £3 million in foreign currency was earned. Space on a commercial basis had been made available for the previous 5 years for Japan, Euratom, France, Italy, West Germany and Belgium. NEI, Vol. 16 No. 170 May 1971 p.373. The money earned in this way contributed to defraying the AEA's R & D costs on the fast reactor. However, in relation to total expenditure foreign currency earnings are not crucial to the survival of the programme but nevertheless valuable. For instance, in 1970-71 £26.3 million was spent on fast reactor systems. UKAEA, Annual Report 1973-74, p.16. For this reason the UKAEA was unwilling to give up these services for overseas customs.

(100) UKAEA, Fifteenth Annual Report p.74, para. 356.


(102) op.cit. p.169 9:42.


(107) Interview
Avery et.al. op.cit. p.55.

Interview

Interview

Avery op.cit.

Interviews

Interviews. See speculation in Nature 30 November, 1968 p.842 "it would be better that this information formed part of the tripartite agreement than if West Germany were to proceed alone".

See chapter 12.

L.G. Wansink, Ministry of Economic Affairs, The Hague, Netherlands, Development of International Undertakings for Uranium enrichment. Urenco experience, Nuclear Power Experience. Proceedings of an International Conference 13-17 September, 1982 Vol.3 Nuclear Fuel Cycle IAEA, Vienna, 1983 p.466 (Paper No. IAEA - CN42/9c) He concluded that the model of co-operation chosen and developed by them has not only provided their industry with a competitive position on the world market, but also clearly contributed to an effective international supply of enrichment services in harmony with non-proliferation principles. p.471.


Avery et.al. op.cit. p.57 Wilson notes that only enough information as necessary was divulged by the British in order to enable officials to assess the extent of developments in the Netherlands and FRG. Ibid.


NEI, Vol. 16 No. 184 September, 1971 p.684, Avery
et al. p.57.


(123) op.cit. p.25.


(128) see chapter 12.


(130) NE, Vol. 11, No. 119 April 1966 p.265.

(131) UKAEA, Thirteenth Annual Report p.83 para. 443. Although a bilateral agreement between HMG and the FRG terminated on 31 July, 1967, arrangements were made to ensure continued collaboration both bilaterally and within the EURATOM framework.


(133) Select Committee op.cit. p.xxxv para 107.

(134) NE, Vol 10 No. 104 January 1965 p.3.

(135) NE, Vo. 10 No. 108 May 1963 p.169.


(140) UKAEA, Sixteenth Annual Report p.73, para. 348 and Fifteenth Annual Report p.79 para. 396; V.S. Emelyanov, The Dilemmas of Non-Proliferation Policy: The Supplier Countries in David Carlton and Carlo Schaerf, The Arms Race in the 1980s, MacMillan
A collaborative agreement was concluded with Brazil in 1968 Cmnd 3816.


Interview

Walker and Lonnoth op.cit. p.30.

New Scientist, 8 February, 1968 pp.286-7

NE, Vol. 13 No. 147, August 1968 p.632.


see chapter 10.

NEI, Vol. 14 No. 154 March 1969 p.161 NEI concluded that, "one of the achievements of the BNX was its publicity of British reactor systems in many overseas states where nobody had really thought about nuclear power before. It established many useful contacts which if followed up energetically by one of the industrial groups might eventually lead to an order."

Roger Williams, The Select Committee on Science and Technology: First round, Public Administration, Autumn 1968, pp.304-5.

CHAPTER 6

(1) Nuclear Energy, Vol. 20 No. 6, 1981, p.450


(4) Duncan Burn, Nuclear Power and the Energy Crisis, MacMillan Press Ltd., 1978 for the lack of commercial freedom argument, Mason Willrich and Theodore Taylor, Nuclear Theft: Risks and Safeguards. A Report to the Energy Policy Project of the Ford Foundation, Ballinger Publishing Company, Cambridge, Mass. 1974 p.185 for the influences of the military programme; Interviews for organisational weaknesses of the consortia system. Originally there were five, and very nearly six, which was like having 'five Concorde projects'.


(14) ibid.

(15) see Chapter 12. Pakistan clandestinely acquired materials for a gas centrifuge plant through Middle Eastern front companies which claimed the end-use was for a textile mill. Norman Moss, The Politics of Uranium, Andre Deutsch, London, 1980, p.192.


(17) The Economist, 28 July, 1975 p.82.


(21) Williams op.cit. p.231.


(25) Nucleonics Week, 1 August 1974, p.5.

(26) Williams op.cit. p.255.

(27) op.cit. p.258.

(28) JBNES, Vol. 16 No. 2 April 1972.


(33) Second Report op.cit. p.xii-xiii para. 41.

Canada lost out on a deal with Argentina because of insistence on strict safeguards. The Atucha 2 reactor order was placed with a German Company, KWU, because the West German Government required fewer safeguards, or so it was thought. Daniel Poneman Nuclear Power in the Developing World, George Allen and Unwin, London, 1982 p.80. "In April 1980, the Canadian Embassy in Bonn publicly expressed disappointment that non-proliferation safeguard requirements did become an element of competition for the Argentine sale, despite a previous commitment from West Germany to accept Canada's position on the need for fullscope safeguards as a non-negotiable condition of sale. Just before the contract was awarded, the German-Swiss consortium apparently broke this agreement with Canada by dropping the requirement for full scope safeguards". E. Regehr, Simon Rosenblum Canada and the Nuclear Arms Race, James Lorimer and Company Publishers Toronto, 1983 Chapter 6, G. Edwards, Canada's Nuclear Industry and the Myth of the Peaceful Atom pp.147.
A decision to opt for a LWR would assist the considerable export business now enjoyed by domestic makers of nuclear pumps, vales and piping in British Industry.

**For instance,** highly enriched uranium hexafluoride (UF₆) is too dilute to use directly in any practical type of fission bomb. Moreover, BNFL do not provide HEU as UF₆ commercially, the level of enrichment is usually 3% U235. Whilst plutonium oxide could be used in a nuclear device, the critical mass of plutonium oxide is somewhat greater than that of plutonium metal. A high PU240 content would increase the critical mass considerably. Willrich and Taylor op.cit. p.14. p.18.

**For instance,** highly enriched uranium hexafluoride (UF₆) is too dilute to use directly in any practical type of fission bomb. Moreover, BNFL do not provide HEU as UF₆ commercially, the level of enrichment is usually 3% U235. Whilst plutonium oxide could be used in a nuclear device, the critical mass of plutonium oxide is somewhat greater than that of plutonium metal. A high PU240 content would increase the critical mass considerably. Willrich and Taylor op.cit. p.14. p.18.
(68) Spain, 10-15,000 te, 850 te for FRG New Scientist 4 July, 1974, p.28; Nuclear Fuel, 15 November, 1976 p.16.


(71) NEI, Vol. 27 No. 344 November, 1982 p.54.

(72) Licensing arrangements were concluded with Westinghouse and a Franco-Belgian Nuclear Fuel Company. NEI, Vol. 24 June 1979 p.6.

(73) Interviews.

(74) Letter to the Author L.G.T. Panton, Assistant Commercial Director, BNFL, 17 December, 1984. 50% of the business was in Europe. 20% in the US and the remainder in the Far East and Latin America. The company also tried to market licenses for converting UF₆ to UO₂ in Spain, Italy, Japan, Nuclear Fuel 30 March, 1981 p.9; Interview


(79) NEI, Vol. 22 No. 265 December, 1977 p.25. Since the date was pushed back to 1980 the rate of installation declined correspondingly.


(82) New Statesman, 12 March 1983.


(86) NEI, Vol. 208 No. 270 April 1978 p.3.
(87) NEI, Vol. 23 No. 275 August, 1978 p.3.
(88) see discussion of this issue in chapter 12.
(90) op.cit. col.620.
(91) BNFL, The Capenhurst Story (Broadsheet).
(96) see footnote 93.
(97) Wansink op.cit.
(99) see chapter 5.
(100) BNFL, Seventh Annual Report and Accounts 1977/78 p.9 para. 16.
(103) Nuclear Fuel, 6 February, 1978 p.3, and 12 December, 1977 p.6. The company hired International Energy Associates of Washington to assist in its marketing in the US. Con Allday, BNFL, noted that," the US market was 'potentially very large and we're only looking for a few percent of it"; Interview.
Although reprocessing had initially been seen as a highly lucrative business, a reassessment of the market potential in the early 1970s led to a downgrading of previous estimates. In anticipation of an over supply BNFL, Cogema and a German Company formed United Reprocessors GmbH in 1971 to divide up the international market and prevent disaster for any one of them. Wynne op.cit., p.36. However, as West Germany had no reprocessing plant, it was left to COGEMA and BNFL to divide up reprocessing contracts, which is what in fact happened to the Japanese deal.

Separate talks continued between URG and two Japanese utilities.
(124) Dr. David Owen speech on 19 May 1977 At the Royal Institute of International Affairs.

(125) Owen op.cit. pp.12-13; cited in Department of Energy's Proof of Evidence to WPI Transcripts Day 42 11 August, 1977, p.56B, A BNFL proof made a similar point BNFL 42 p.31. This position was reflected in Lord Silsoe's (BNFL's counsel) final submission. Transcripts Day 99 3 November 1977 p. 27 C, D, G, p.36 D, E.


(127) Transcripts Day 43 14 August 1977 p.144. H

(128) op.cit. p.13B see also Silsoe pp.9-10H Day 1 14 June 1977.


(132) Transcripts Day 31, 27 July, 1977 p.73D.

(133) Transcripts Day 31, 27 July, 1977 p.74 G; Interview


(137) Nuclear Fuel, 13 September, 1982 p.3. 6000 te over a 10 year period. 3100 for utilities in Japan, FRG, NL, Sweden, Italy and Spain; 2900 for CEGB/SSEB, and for 150 UKAEA. But delays in operating AGRs and increased burn-up in AGR fuel made excess capacity available.


(139) In addition to fuel cycle services it provided miscellaneous services including provision, modification and hire of flasks for irradiated fuel transport, sale of depleted uranium, sale of magnesium fluoride. These total less than 2% of mainstream fuel activities. L.G. Panton, Assistant
Commercial Director, BNFL Letter to Author 25 January 1983.


(147) Interviews.


(150) UKAEA, 1976/77 op.cit p.9 para. 24.

(151) UKAEA, Annual Report 1973/74 p.34 para. 32.


(154) BNFL Fuel Service Export Earnings 1971-1983

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<th>Year</th>
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<tr>
<td>1982/83</td>
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</table>

Source: BNFL Annual Reports. In 1979/80 BNFL were awarded the Queen's Award to Industry for Export Achievement. BNFL, Ninth Annual Report and Accounts 1979/80 p.73.

(155) On Argentina see Jorge A. Aja Espil, Argentina in Non-Proliferation the Why and the Wherefore ed Jozef Goldblat, SIPRI, Taylor and Francis, London 1985 p.75 also chapter 7b Ashok Kapur Pakistan pp.142-3 and for India Chapters 5A, 5B Girilal Jain, Rodney W. Jones.
CHAPTER 7


(3) Marshall op.cit. p95

(4) Marshall, op.cit. p.95.


(6) Patterson, op.cit. p.69.


(9) Gowing Vol. 11 Policy Execution p. 270

(10) ibid.

(11) Dr. Tom Marham (Managing Director, Northern Division UKAEA), Atom, May, 1983; see also New Scientist 21 March, 1974 p.745.


(15) Nucleonics Week, 4 September 1975 p 8 see also UKAEA, Annual Report 1976/77 p. 8 para.14 £5.5 million.
(16) UKAEA, Annual Report 1976/77 p. 8 para 14

(17) Franklin and Hill op. cit. p.427.

(18) UKAEA, Fifteenth Annual Reports And Accounts 1968-9 p.6 para 33.


(20) op. cit. p7 para 14.


(22) UKAEA, Annual Report 1981/82 pp6-7 para 10.

(23) Franklin and Hill op.cit. p427.

(24) Franklin and Hill note, for example, that the fuel fabrication facilities at Windscale, although adequate for PFR, would need to be expanded and the processes themselves altered in the future plants supplying commercial reactors. ibid.

(25) Franklin and Hill op.cit. p.433


(27) Gowing notes, "Coal shortage was the reason why efforts must be made to produce electric power from atomic energy. Ever since the subject had been discussed in war it had been generally agreed that in the long term the best method would be the fast fission breeder reactor, which would produce both heat and power and at the same time breed more fissile material than it burned." Gowing Vol. 1 op.cit. p.444.


(29) The Trend Report observed in 1954 that, "The supply of coal will remain a difficult problem for a number of years. Special coals, such as prime quality carbonisation coals, anthracites and dry steam coals, as well as the larger sizes of "general" coals, will probably be the most scarce". AB16/1475 p.15 para.22. The Trend Report also thought. "Plutonium is potentially valuable as a nuclear fuel and an expanding nuclear system should, therefore, be such as to encourage both its production and its subsequent utilisation on the most economic line", p.21 para.44.


(31) N.L. Franklin, R.B. Kehoe (UKAEA, Risley), Plutonium: Reserved for Fast Reactors, Nucleonics Vol.24. No.9 September, 1966 p.66. See also The Economist, 17 June,
1961, p.1230. "Plutonium must work as a fuel, and must work in Dounreay because the future nuclear power programme rests on the assumption that plutonium provided by the ton in the CEGB's nuclear power stations - is a nuclear fuel of considerable commercial value" and UKAEA, Eighteenth Annual Report and Accounts 1971/72 "...in the United Kingdom, plutonium should be stored for use in fast reactors". p.15 para.18.


(34) UKAEA, Annual Report 1973/74 p.24 para.74. Dr. Tom Marsham, then Director of the AEA's Reactor Division, "believes that the fast reactor programme is the most important part of the United Kingdom's energy policy, and that the success of this programme is crucial. It could help to re-establish the UK nuclear industry on the world scene". New Scientist, 21 March, 1974 p.745.

(35) UKAEA, Annual Report 1973/74 p.8 para 12. There was no change in the Authority's corporate view the following year. "The Authority review a range of future patterns of electricity and energy demands when assessing the scale and balance of their development programmes. These views have directed attention to the escalation in the world price for uranium as a key item affecting the need for fast reactor power stations in the future. The projected increases in thermal reactor systems throughout the world will use not very efficiently substantial proportion of known reserves. With the increased cost of uranium which will follow, the much more efficient utilisation of fuel in a fast reactor is highly desirable. UKAEA, Annual Report 1974/75 p.25 para.78, Annual Report 1975/76 p.5 para.4 see also R.G. Mattocks, D.J. Mathias, Atomic Power Company Ltd, The Power Programme, Journal of the Institution of Nuclear Engineers. November/December 1974 pp178-9. In advancing the reasons for a fast reactor programme these authors noted, "guaranteed supply of fossil fuels can no longer be regarded as the basis on which an economic electricity supply system can be planned for the future in this country. The development of the Breeder system could make us independent of external supplies and production of fuel in the UK would demand only a
discrete labour force".


(37) Atom, No. 324 October, 1983 p.212. Although apparently less enthusiastic the CEGB noted in their Annual Report and Accounts 1980-81 that, "The Board continues to support the development of fast reactors so that they can become a viable option by the time the need arises, which is likely to be early in the next century" p.24 para.95. The AEA, despite the recession and consequent decline in the fortunes of civil nuclear power worldwide, was still able to assert in 1983 that the fast reactor, "has the ability to reduce and eventually eliminate the need to import new supplies of uranium and has thus an essential role to play in complementing thermal reactors". UKAEA, Annual Report 1979/80 p.5. para.5.


(39) Sir Peter Hirsch, Fast Reactor: Perspective and Prospects (Sir John Cockcroft Memorial Lecture) Nuclear Energy, Vol.22 No.6 1983 p.415. Hirsch also noted that, "the case for the fast reactor on grounds of long term security of supply is clear, date of introduction of commercial fast reactors depends on ability to produce economically", p.401. In November, Marshall, who was then Chairman of the UKAEA, and Chief Scientific Advisor at the DEN, argued that the fast reactor "was essential as ever, and Britain must continue to develop it to a point where it can be introduced on a commercial scale when it is required in about 20 years time. Without fast reactors, nuclear power can make a useful but comparatively short-lived contribution to the world's energy supply. With the fast reactor nuclear power becomes the most important world energy source of the future. In Britain today we have stocks of depleted uranium which, used in fast reactors, represent an indigenous energy source roughly equivalent to our recoverable coal reserves of some 45,000 million tons and dwarfing all present estimates of oil reserves in the North Sea". Atom, No.301 November, 1981 p.281.


(41) Atom, No.218 December, 1978 p.278.

(42) Atom, April 1984 p.15.


Nuclear News, October 1979, p.38. Particular care and attention was given to the preparation of speeches, lectures and statements made by the Chairman and Deputy Chairman. Interview. Such major statements were the product of substantial internal consultation. Marshall, in this case, acknowledges the assistance of several key individuals from both the nuclear industry and Whitehall. Amongst those consulted Marshall includes Sir John Hill, Chairman UKAEA and BNFL; Lord Flowers, UKAEA Board Member; Philip Searby, UKAEA Secretary; Con Allday, Managing Director BNFL and part time UKAEA board member; Dr. Donald Avery. BNFL; Tony Farmer, UKAEA Reactor Division; Ivor Manley, Atomic Energy Division, Department of Energy; Patrick Moberley, Assistant Under Secretary of State whose field of responsibility included arms control and nuclear energy in Foreign and Commonwealth Office. There are, therefore, ready reasons for regarding the Marshall Atom article as a reasonably representative reflection of British attitudes.

Marshall 1980 op.cit. p.96

ibid.

Marshall, 1980 p.97 Marshall observed in 1978 that, "a policy of using thermal reactors alone in the once-through fuel cycle is not a satisfactory non-proliferation policy because, in essence, every fuel storage facility, wherever it is placed becomes a "plutonium mine". This means that each reactor cooling pond, each national fuel element store or regional fuel element store becomes a "plutonium mine" and the plutonium in that mine becomes steadily more accessible as time goes on. In effect a storage policy sets off a proliferation time clock. With this policy every nation with a nuclear power plant and a spent fuel element storage facility has set up a target for plutonium diversion and has established an option to construct weapons in ways that are easier and easier to operate as the stored plutonium becomes..."


(51) ibid. The National Nuclear Corporation shared the same outlook: "fast reactors would be a contribution towards western energy self-sufficiency, an incidental effect on which would be the liberation of some supplies of fossil fuel resources for countries in which, for one reason or another, nuclear stations are unsuitable." David Gosling and Hugh Montefiore eds. Nuclear Crises: A Question of Breeding. Prism Press. London, 1977 p.149.


(53) ibid.

(54) Walter Marshall, Nuclear Power and the Proliferation Issue. Atom, No. 258 April 1978 p.91. This paper was first presented at the Graham Young Memorial Lecture, University of Glasgow, 24 February 1978 see footnote 48.


CHAPTER 8

(1) See chapter 4.


(4) SIPRI 1979 op.cit.


(8) ENDC members UK, USA, Soviet Union, Sweden, France (did not take seat), Italy, Canada, Czechoslovakia, Poland, Nigeria, U.A.R. Burma, Ethiopia, Brazil, Mexico, India, Romania, Bulgaria.

(9) Reference to Articles 111, 1V and VI is as they appear in the final text of the treaty.

(10) The US, UK and Soviet Union gave undertakings to assist states signing the projected non-proliferation treaty if they were subjected to nuclear blackmail or attack. The Times, 8 March, 1968 p.5, Shaker op.cit Vol.2 pp475-76.


(13) Goldblat op.cit. pp279-80.

(14) Disarmament: The Road to Peace, London, HMSO p.4 para.27.

(15) In a letter to the author Fred Mulley, who was Minister of State at the FCO declined to be interviewed, but stated that he doubted if he could add significantly to what can be learned from published documents. A FCO official has also stated in relation to the NPTRCs that the statements of British delegates in the Plenary Sessions are a reasonable reflection of the briefing documents.
circulated within the FCO, but are closed to public inspection under the 30 year rule.


(17) One of the rationales for British possession of nuclear weapons was that this allowed access to the "top table". Lord Chalfont speaking at the 74th meeting of the Disarmament Committee on 28th April, 1965 remarked that nuclear weapons were considered as a measure of national prestige. "My own country has in the past been much to blame with its insistence on national nuclear weapons as the entrance ticket to the 'top table' of international conferences. It is a mistake which I hope we shall never make again". Further Documents on Disarmament. The Disarmament Negotiations 1965 (in continuation of Misc. No. 8 (1965) Cmnd 2695) July, 1966 Cmnd 3020, HMSO, London p.65.


(26) Freedman op.cit. pp.327-31 ANF was to consist of an equal number of British and American Polaris submarines with a mixed crew Polaris surface fleet on the MLF pattern all under NATO command. The V-Bombers would also be included.

(27) Shaker Vol. 1 op.cit, p.188.

(28) Cmd 3020 op.cit. See Polish criticism of MLF/ANF and that the British view cannot be reconciled with the objectives of a non-proliferation treaty p.19.


(34) For the argument that the British "sabotaged" the MLF proposals see John Baylis, Anglo-American Defence Relations 1939-1980. The Special Relationship, MacMillan Press Ltd., London, 1981 pp.87-89. Baylis also argues that the ANF proposal represented an attempt by the British Government to retain its planned Polaris force.

(35) The US, however, does make available nuclear weapons for NATO states under Programmes of Co-operation. This involves the transfer or the deployment of nuclear weapons on foreign soil for support of foreign forces. The US controls the warhead, the Europeans, the delivery system: missile, aircraft, or artillery for example. POCs exist with eight NATO states: Belgium, Canada, Italy, The Netherlands, Turkey, Britain and the FRG. The Pershing 1a with 2 "wings" equipped with 36 launchers and missiles is utilized by the West German Air Force for medium range support. FRG units are trained for the use of the following US warheads, W31, W33, W43, W48, W50, B61, W70. Thomas B. Cochran, William M.

(36) Shaker Vol. 1 op.cit. pp.233-4 see also chapter 3 p.123. p.102 where he describes the Gromyko-Rusk meeting as "a turning point towards the conclusion of the NPT".


(38) Shaker Vol. 1 op.cit. p.294.


(40) Goldschmidt op.cit. p.197.

(41) op.cit. pp.188-9, 192.

(42) op.cit. pp.118-9.

(43) New Scientist, 3 January, 1957 p.46.

(44) IAEA Safeguards an Introduction, IAEA, Vienna, 1981 IAEA/SG/INF/3 pp.3-4; see chapter 10.


(48) ibid.


(51) Cmd 3940 op.cit.

(52) see chapter 10.
(56) Young op.cit. p.11.
(57) see chapter 5.
(60) see chapters 5 and 6.
(63) Cmnd 3767 op.cit. p.8.
(64) Cmnd 3940 op.cit. p.10.
(65) see chapter 10.
(66) see Brazilian position, Cmnd 3767 op.cit. and Nigerian position p.14 op.cit. For US draft see Cmnd 3020 op.cit, pp.30-32.
(68) see Article IV para. 2 in particular. see chapter 6.
(69) see chapter 4.
(70) Cmnd 3940 op.cit. p.61.
(71) ENDC/PV 337, 10 October, 1967 para. 42.
(72) Cmnd 3767 op.cit pp.153-4.
(73) Cmnd 3878 op.cit. pp.238.
(74) Interview.
(75) Arms Control and Disarmament 6 August, 1968, Foreign Office.
(76) see chapter 5.
(77) Cmnd 3940 op.cit. p.204.

(79) Leonard Beaton noted in 1969 that the British approach to control of sensitive technologies was based on faith in the political power of the NPT. The Times, 23 January, 1969, p.16.

(80) Cmd 3767 op.cit p.9.

(81) Cmd 3767 op.cit.


(83) Cmd 3940 op.cit. p.163.

(84) Young op.cit. p.14.

(85) ENDC/PV 369, see also ENDC/PV 373.


(94) Cmd 3767 op.cit. p.103.

(95) Cmd 3767 op.cit. p.59.


(97) Cmd 3767 op.cit. p.34.

(98) see chapters 6 and 12.
CHAPTER 9

(1) The August 1975 R.C. had three Prep. Comm. meetings: 1 - 8 April, 1974; 26 August - 6 September 1974; 3 - 14 Feb 1975. For its first two meetings the Committee was composed of 26 members. At its third session a further six participated, NPT/CONF/35/1 p.1. The 1980 Prep. Comms. met on 17 - 20 April 1979; 20 - 24 August 1979; and 24 March - 1 April 1980. At its first two sessions 39 - 40 states participated, for the third meetings a further three took part. NPT/CONF/11/22/3 p.l see also Arms Control and Disarmament Developments, in the International Negotiations, ACDRU, FCO No. 1 August 1979 p.16.

(2) The discussions which led to the consensus Final Declaration at the 1985 NPTRC went on late into the night on the last day. The Observer, 22 August, 1985 p.2.


(4) NPT/CONF/11/22/1 Annex 111 p.35. ACDRU was established in January 1965. It should also be noted that A. Barlow was on secondment from the UKAEA.

(5) Interview.

(6) David Summerhayes, leader of the 1980 Delegation, noted on Saturday 6 September, 1980 that "the absence of a final declaration after four weeks of discussions would benefit no one and was a matter for regret". NPT/CONF/11/SR 19 p.149.
(7) NPT/CONF/35/111. S.R. 3 p.32.
(9) NPT/CONF/35/111 SR 3 p.31.
(10) NPT/CONF/35/111 SR 3 p.29.
(11) NPT/CONF/C.11 SR4 p.262.
(12) op. cit. p.263.
(14) On the penultimate day of the Conference Allen stated that the text of the Final Declaration dealing with Articles III, IV and V was satisfactory. NPT/CONF/ SR14 p.134.
(16) NPT/CONF/C.11/SR11 p.314. Jackson notes that for the UK INFCIRC/66 precludes the use of nuclear energy for any military purpose. This would suggest that INFCIRC/66 was suitable for UK exports even though not all facilities or materials in the importing state were safeguarded as would be the case under INFCIRC /153 (Corr).
(17) NPT/CONF/35/1 Annex 1 p.4.
(18) NPT/CONF/C.111/SR2 p.240.
(22) NPT/CONF.11/SR.3 p.28 see also Cromartie NPT/CONF. 11/C.11/SR27 p.295. The NSG had been attacked on the grounds that it was a secret conclave; but the result of its work had been published in extensio in IAEA document INFCIRC/254 and in related documents circulated to all member states, containing the understanding reached by the Group. The guidelines relating to exports fell into two distinct categories: one dealing with sensitive items and the other with non-sensitive items.
(23) NPT/CONF.11/SR.3 p.28.


(26) ibid.


(28) NPT/CONF.11/SR.3 p.28.

(29) ibid.


(32) see for example Swedish statement on 22 August, summary records of Main Committee 1 NPT/CONF.11/C.1/SR5 p.181. "The fact that the provisions of article VI had not been fulfilled must be appropriately reflected in the final document."

(33) see Group of 77's Working Paper NPT/CONF.11/C.1/2 which had a great deal to say about the NWS failure to fulfil their obligations under Article VI, and in particular, the failure to produce a CTBT was singled out.

(34) Tripartite Report to the Committee on Disarmament NPT/CONF.11/13 p.5.


CHAPTER 10


(2) ibid.

(3) Interview.

(4) Fischer op.cit.

(5) NPT, Article III para. 4.

(6) Fischer op.cit. p.168, the final discussions were held in New York between 20 September and 26 October 1956. UKAEA, First Annual Report 1954-1955, p.32 para. 184.


(10) Interview.


(12) see chapter 8.

Scientists, March 1967 p.36.

(14) ENDC/207, see also Hansard, Vol. 755, No. 25, col. 963.

(15) Sizewell B Public Inquiry, Transcripts op.cit. p.61C; Interview.

(16) Nuclear Engineering, December, 1965 p.911. The first inspection was held on 27 October led by IAEA inspector Gerald A.D. Knight. It was hoped that this would provide a pilot project for applying safeguards. Bradwell was covered by INFCIRC/86 1 September 1966. Between October 1968 and July 1981 IAEA inspectors paid 50 visits to the UK. Hansard 22 July, 1981 col. 125 written answers.

(17) SIPRI, Safeguards Against Nuclear Proliferation, SIPRI Monograph, Almqvist and Wiksell, Stockholm, 1975 p.28.


(27) Interview.
(28) Interview.


(34) Sizewell B Public Inquiry Documents, BNFL/P/I (Add2).

(35) Sizewell B Public Inquiry Transcripts, Day 274 16 October, 1984 p.51 F.

(36) op.cit. p.62C.

(37) Interview.

(38) Sizewell B Public Inquiry, Transcripts Day 274, 16.10.84 p.63G.

(39) Sizewell B Public Inquiry Documents, R.V. Hesketh, Nuclear Power UK, Nuclear Weapons USA. A proof of evidence on behalf of CND, CND/P/1 September, 1984 see also CND/P/1 (Add 2); R.V. Hesketh, the Export of Civil Plutonium, Science and Public Policy Vol. 9 No. 2 April, 1982 pp.64-70.


(41) David Lowry, Reflections on Britain's Nuclear History: A Conversation with Lord Hinton, ERG 048 Open University Energy Research Group p.27.

(42) Sizewell B Public Inquiry Transcripts Dr. Donald Avery, Day 274, 15/10/84 p.55D.


(49) Brown op.cit., see also J.H. Marshall ed. Safeguards Approach for Gas Centrifuge Type Enrichment Plants, Nuclear Materials Management No. 4 Winter 1983.


(51) Interviews.


(53) Sizewell B Public Inquiry Transcripts, Hugh Sturman BNFL, Day 274 Tuesday 16 October, 1984 p.57 C.


(55) Interviews.

(56) Nucleonics Week, 2 October, 1975 pp.5-6.


(60) Hansard, Tam Dalyell, 18 December, 1979 cols. 554-563.

(61) Hansard, Norman Lamont, Minister of State, Department of Energy, 18 December, 1979 cols. 569-870.

(62) Nucleonics Week, 28 June, 1979 p.11.

(63) ibid.

(64) Hansard, 18/12/79 col. 576.

(65) Nucleonics Week, 5 July, 1979 pp.4-5.
(66) Nuclear Fuel, 26 October, 1979 p.11.
(67) Nucleonics Week, 5 July, 1979 p.3.
(68) ibid.
(69) ibid.
(70) Interviews.
(72) Journal of the Institute of Nuclear Engineers, Vol. 18, No. 4, p.124.
(74) ibid.
(75) Safeguards against Nuclear Proliferation, SIPRI, 1975 pp.6-7.
(77) ibid.
(81) op.cit. p.53 Other work was done in the UK on safeguards procedures on applications of safeguards controls at research facilities and stores, development and application of surveillance and monitoring devices for different types of plants. Anderson, 1977 IAEA-CN/-36/76 p.418.
(82) IAEA, Annual Report 1980, p.43, "comprehensive assistance was given to the HSP, for example Annual Report 1981 p.81.


(84) Fischer and Szasz 1985 op.cit. p.67.

(85) IAEA, Annual Report 1982 p.66. Other members of SAGSI include the US, France, FRG, Canada, Japan, Australia, Czechoslovakia, the Soviet Union, Yugoslavia, India and Brazil. In short, the leading nuclear powers from the East, West and South.


(87) Interview.

(88) see Leslie Hannah, Engineers, Managers and Politicians the First Fifteen Years of Nationalised Electricity Supply in Britain, MacMillan Press Ltd., London, 1982.

(89) Sizewell B Public Inquiry Transcripts. H. Sturman, BNFL, Day 284 16/10/84 p.56 G.
CHAPTER 11


(2) Nuclear Engineering International, August, 1982, p11

(3) Nucleonics Week 7 June, 1979, p2


(5) Ian Smart, Janus: The Nuclear God. The World Today. April, 1978 p121


(7) Hansard, 17 May, 1977, col.80 written answers


(10) Nuclear News, April 1980

(11) Phillip Gummet, From NPT to INFCE Developments in thinking about Nuclear Non-Proliferation, International Affairs, Autumn, 1981, No.4, p553


(13) op.cit., p2
Working Group 1 - Fuel and Heavy Water Availability (Co-Chairman: Canada, Egypt, India);
Working Group 2 - Enrichment Availability
Working Group 3 - Assurances of Long-Term Supply of Technology, Fuel and Heavy Water and Services in the Interest of National Needs Consistent with Non-Proliferation (Co-Chairmen: Australia, Phillipines, Switzerland);

Working Group 4 - Reprocessing, Plutonium Handling, Recycle (Co-Chairmen: Japan, United Kingdom):

Working Group 5 - Fast Breeders (Co-Chairmen: Belgium, Italy, USSR);

Working Group 6 - Spent Fuel Management and Disposal (Co-Chairmen: Argentina, Spain);

Working Group 7 - Waste Management and Disposal (Co-Chairmen: Finland, Netherlands, Sweden);


(14) op. cit., pl

(15) Interview

(16) Interview

(17) Interview

(18) Interviews

(19) Interview


(21) The British thought that it was not through technical inferiority or because the US lagged behind the Europeans in the commercial development of reprocessing that led to US policy. If the Americans had wanted to proceed with both fast reactor and reprocessing development on a commercial scale then they could have done so.

(22) UKAEA, Annual Report 1976/77, p5 para.5

(23) Japan for example is particularly dependent on overseas supplies of oil. In 1975 87% of Japan's oil came from the Middle East, J.E. Endicott, Japan's Nuclear Option. Political, Technical and Strategic
In an article in Nuclear Engineering International, What will be the impact of INFCE? December, 1979, p66 Ryukichi Imai stated that, "Japan cannot afford to reduce her reliance on nuclear energy even if countries better endowed with energy resources may decide to do so." see also Brenner op. cit., p146

(24) Although a nuclear explosive can be produced from reactor-grade plutonium, this would not be the preferred route for a military programme. The principal problem is the presence of large quantities of Pu-240. As this isotope fissions spontaneously this increases the risk of preignition which puts simply is the premature explosion of the nuclear core. This produces a substantially reduced explosive yield. A nuclear explosive can be produced with as little as 2kgs of plutonium provided it is at least 93% Pu-239 and the sphere is surrounded by a beryllium neutron reflector and tamper and has a high-technology implosion system capable of very high rates of compression. The aim is to assemble a critical mass, the minimum amount of material required to sustain a chain reaction, and keep it together for as long as possible so that as many atoms as possible undergo fission before the device blows itself apart. The purpose of the conventional high-explosives surrounding the nuclear core is to compress the sub-critical assembly so that it becomes super-critical and will therefore explode. The presence of large amounts of the even isotopes increases the quantity of plutonium needed which in turn requires higher design standards for the implosion system. Plutonium of reactor-grade containing 70% Pu-239, for instance, has a critical mass of about 6kgs and will produce a yield of about 10kt whereas 4.5kg of weapons-grade will produce a yield in the region of 20kt. The problems of preignition can be overcome with more sophisticated design techniques; however, large amounts of Pu-240 generate more heat which threatens the integrity of the non-nuclear components of the weapon. The need to dissipate the extra heat causes further design problems which is the principal reason why reactor-grade plutonium is not used in nuclear weapons. Moreover, this material is more difficult and is dangerous to handle.

(25) Interview
(26) Interview
(27) see Chapter 2 for discussion of dual-purpose reactors and first nuclear power programme in the 1950s
(28) Interview

(30) op. cit., p3 Technology, Environmental Impact; Economics; Use of Energy resources; the risk of proliferation; safeguards; institutional arrangements; special needs of developing countries

(31) see chapters on British nuclear exports and NPT negotiations


(33) Gummett, op. cit., p565

(34) UKAEA, op. cit., p6, para 8

(35) Working Group 4 op. cit., p11 para 30

(36) op. cit., Table XX, Alternative Forms of Plutonium noted that the conversion time from MOX fuel to plutonium metallic components of nuclear explosive was between 1 and 3 weeks. (max. mixed oxide)

(37) op. cit., p.11 para 20

(38) see discussion of Cabinet Defence Committee and Cabinet Conclusions 1952-1954 in chapter 2

(39) Working Group 4, op. cit., p12 para 34

(40) For example, at the 1955 UN Geneva Conference on the Peaceful Uses of Atomic Energy British scientists presented papers relevant to reprocessing and plutonium handling such as Chemical principles in the separation of fission products from uranium and plutonium by solvent extraction. P/413, J.M. Fletcher; Chemical processing of fission product solutions P/415, E.Glueckraut and T.V. Healey; Tri-n-butyl phosphate as an extracting agent for the nitrates of the actinide elements, P/441, H.A. McKay, First International Conference on Peaceful Uses of Atomic Energy, Geneva, 1955, Vol.16, Annexes


(42) IAEA, Annual Report of the Board of Governors to the General Conference 1 July, 1967 - 1968, GC (XXII)/380, pl. Fuel from the Yankee Atomic Power station was reprocessed at Nuclear Fuel Service Inc., West Valley, New York, p30, para.120
Papers submitted to the group by the British include: INFCE/DEP/WG4/118 Safeguarding a Future Industrial Reprocessing Plant, United Kingdom, 24 November, 1978 INFCE/DEP/WG4 To Judge the Degree of Proliferation, 20 November, 1978

INFCE Vol.4 op. cit., (i) National reprocessing facilities; (ii) Reprocessing services limited to large national facilities also serving foreign countries; (iii) Multinational projects and national facilities with multinational participation; (iv) Multinational or regional nuclear fuel cycle centres under IAEA or other international auspices; (v) International fuel authority; (vi) International Plutonium storage.

INFCE Vol.4 op. cit., p18 para 58

ibid.

Windscale Public Inquiry Transcripts, Day 42, 11 August, 1977 p56. This refers to a speech given at the Royal Institute of International Affairs by Dr. David Owen, Foreign Secretary in May 1977. Commenting on American suggestions that reprocessing of nuclear fuel should be limited, Owen stated, "It can be argued that reprocessing and the eventual use of fast breeder reactors would lessen dependence on possibly uncertain uranium supplies for those countries with none of their own." The Times, 20 May, 1977, p7

Windscale Public Inquiry Transcripts, Day 7 Morning 22 June, 1977, p9 Outlining BNFL's case at WPI, Lord Silsoe stated on the First Day that: "Denial of reprocessing services to other countries who have or can develop that technology themselves would place serious pressures upon those countries to reprocess their fuel for themselves". Day 1, 14 June, 1977 pp9-10 H


The Annual Report for 1977, IAEA, GC(XXII)/597, p21 para. 66
For example, Herzig stated that denying access to nuclear technology has put pressure on countries, including the UK, to develop their own. It happened after the Second World War when America tried to keep nuclear technology to itself. *The Times*, 13 August, 1977, p2

The FCO, as Boardman and Grieve observed, was sensitive, "to the wider costs of a refusal to accommodate legitimate developing country needs for nuclear power in the face of spiralling imported oil prices...a non-Proliferation strategy based on a policy of denial was thought inherently contradictory." Boardman and Grieve op. cit., p115

(55) INFCE Vol.4 op. cit., pp18-9 para 59

(56) op. cit., p19 para. 63

(57) Nuclear News, October, 1978, p48

(58) INFCE Vol.9 p122 (Summary of Vol.3)

(59) ibid.

(60) ibid.

(61) Boardman and Grieve op. cit., p112

(62) Nuclear Engineering International, July, 1978, p9 see also Nucleonics Week, 14 April, 1977, p3 "BNFL is worried that any US ban on re-transferred fuel of US origin would remove a large part of the case for expanding its windscale reprocessing plant".

(63) INFCE Vol.9 pp127-132

(64) Nuclear Engineering International, July, 1979, p27

(65) Boardman and Grieve, op. cit., pl16-7


(67) This was the conclusion of Working Group 5 see INFCE Vol.9 p29 para. 105

(68) see for example, Walter C. Patterson, The Plutonium Business and the Spread of the Bomb, Wildwood House, London, 1984, pp141-43

(69) A Report of the TCC for the Final INFCE Plenary Conference, INFCE, Vol.9, pp1-2 section 111 Non-Proliferation Aspects of the TCC's Summary and Overview states, p24 para. 86: "The construction and planned misuse of fuel cycle facilities is not the easiest nor the most efficient route to acquire materials for the manufacture of nuclear weapons. However, if facilities handling a significant amount
of weapons-usable materials are already established, their misuse might well, in some circumstances, be a feasible path to obtaining materials for nuclear weapons. In addition, the technology and know-how acquired in nuclear power programmes though not directly related, could be drawn on for a subsequent nuclear weapons programme". This was the view of Sir Solly Zuckerman in 1966. Zuckerman was Chief Scientific Advisor to the British Government between 1964-1971 and before that Chief Scientific Advisor to the Secretary of State for Defence between 1960 and 1964. For example, "The military and civil exploitations of nuclear technology are not necessarily linked. In our efforts to prevent the proliferation of weapons, we should not, therefore, drive ourselves into the paradoxical situation that we deny a peaceful world the benefits of nuclear energy". The Control of Proliferation: Three Views. Adelphi Papers No 29, October, 1966 p7 Sir Solly Zuckerman, Ambassador Alva Myrdal, Rt. Hon. Lester B. Pearson.

(70) TCC Summary and Overview op. cit., pp30-31 para 110
The US tested such a device in 1957. T.B. Cochran, W.M. Arkin, M. Hoenig, Nuclear Weapons Databook Vol.1 US Nuclear Forces and Capabilities, Ballinger, Mass. Cambridge, 1984, p24 The most likely yield would have been between 1 and 10 kilotons. Since the best emplacement for such a test was from a tower all that need be done is check the yields of all US nuclear tests conducted from towers in 1957. see M.W. Carter and M. Moghissi, Three Decades of Nuclear Testing, Health Physics, Vol.33 July, 1977, p61 Frank Barnaby notes that the US has tested at least two such devices. Consequences of the Plutonium Economy Presented on behalf of the Stop Sizewell B Association and Ecoropa, Sizewell B Public Inquiry SSBA/p/12

(71) INFCE Vol. 2 p32 para 17

Robert Press was Deputy Secretary Science and Technology, Cabinet Office Between 1974-1976, Advisor to the CO since 1976. Amongst other posts Press was in the Department of Atomic Energy, Ministry of Supply, 1948-1951 and Assistant Chief Scientific Adviser (Nuclear) Ministry of Defence 1963-1966. This quotation goes on to say that: This is a major priority and it will require greater political trust in assisting those whose established economic need is an assured national energy supply. The approach should be evolutionary in leading to greater certainty about the terms of nuclear trade, including
technology transfer, particularly non-sensitive technology, and more effective measures on nuclear arms control ... Failure to restore confidence in the credibility of long-term supply arrangements can be expected to encourage developing countries to establish their own nuclear facilities free from external controls. On the other hand, guaranteed supplies of materials, enrichment or reprocessing services might well postpone pressure to these technologies at least until shown to be economically necessary". p23

(73) INFCE. Vol. 9 p39 para.136
CHAPTER 12


(4) Interview, Wilmshurst op. cit. p.29.

(5) Douglas Hurd, Minister of State, FCO 1980 NPTRC, NPT/CONF 111/SR3 p.28; Interviews. Wilmshurst, Counsellor at FCO 1974-1978, noted that its basic purpose was to prepare a uniform code of nuclear export behaviour which would serve as a minimum standard. op. cit. p23.

(6) Interview.


(9) Interview, Wilmshurst op. cit. pp.28-29

(10) Nucleonics Week, 13 November 1975 p.2

(11) Nucleonics Week, 5 February 1976 p.3

(12) Also commended IAEA recommendation on physical procedures to customers and ban on the use of their exports for use in PNES. Nucleonics Week, 5 February, 1976 p.3


(14) Nucleonics Week, 2 December, 1976 p.10
(15) Nucleonics Week, 2 December, 1976 p.10. Given that the NSG met in secret it is not surprising.

(16) see Chapter 10

(17) Nucleonics Week, 2 December, 1976 p.10


(20) Nucleonics Week, 5 October, 1978 p.11


(22) Fischer op.cit. p. 103 Conversely, Ian Smart a former British diplomat involved in the negotiations of the NPT argued that INFCIRC/254 codified a progressive abandonment of several principles, 1) export countries alone to present themselves as an international rule-making body flouted the principle of basing non-proliferation negotiations on a general consensus among recipients as well as suppliers, as NPT had been based. 2) NSG's failure to require full-scope safeguards as a condition of nuclear trade both advertised and ratified the demise of preferential trading community intended by NPT. Nuclear Engineering International, May 1983 p.41


(25) Julie Dahlitz, Nuclear Arms Control, George Allen and Unwin, London, 1983 p.141 see also statements of Yugoslavia and Mexico at the 1980 NPTRC NPT/CONF 11/C11/SR 3 p.252; NPT/CONF 11/C11/SR7. Despite complaints by recipients that the NSG was a step towards cartelisation of nuclear supplies, the guidelines, even if honoured faithfully were not especially restricted. They did not forbid trade with countries that made no binding commitment.... they did not require application of full scope safeguards, thereby permitting trade with non NPT countries with unsafeguarded facilities on their territories; they did not prohibit the transfer of sensitive technologies, nor the reprocessing of fuels supplied by a party to the guidelines. William Walker and Mans Lonnroth, Nuclear Power Struggles Industrial Competition and Proliferation Control George Allen Unwin, London 1983 p.160.

(27) see Chapter 11.


(31) Nuclear Engineering International, August, 1982 p.11

(32) NPT/CONF/35/1 Annex 1 6, see also Internationalization To Prevent The Spread of Nuclear Weapons, SIPRI, Taylor and Francis, London 1980 p.21.

(33) Two other proposals of US origin, Multinational spent fuel centres and an international nuclear fuel authority, were studied or examined as much as the other three. For details see David Fischer and Paul Szasz, Safeguarding the Atom. A critical appraisal edited Jozef Goldblat, SIPRI, Taylor and Francis, London 1985 pp 113-115; IPS and MRCC were examined by the IAEA.


(37) see chapter 6.


(40) ibid.

(41) Regional Nuclear...op. cit. p.51 para 6-7.

(42) see chapter 6.

(43) Regional Nuclear op.cit. p.59 9.3.

para 24-27.

(45) Smart op.cit. p.22.
(46) Smart op.cit. p.28.
(47) Preface.
(50) Nuclear Fuel, 26 May, 1980 p.2
(51) see chapter 7.
(52) Interviews
(54) Interview
(57) Nuclear News, May 1978 p.53
(58) Nucleonics Week, 9 February, 1976 p.8
(61) Nuclear News, August, 1978, p.56 Nuclear News, May 1978 p.55. However, the scope for independent action is restricted by the Tripartite Treaty which established Urenco
(62) Interview
(63) Nuclear Fuel, 26 May 1980 p.2
(64) Fischer op. cit. pp.115-116
(65) Interview
(66) Interviews
(67) Fischer op.cit.p.113 MFCC was a difficult concept to put into effect, in particular the details of
managing and operating of a commercial undertaking were not inconsiderable.

Interview: Fischer op. cit. pp.112-3;

(68) see statement of Philippines at 1980 NPTRC, NPT/CONF.11/22/11; NPT CONF.11/C.11/SR.8 p.304

(69) see chapter 9

(70) United Nations Disarmament Yearbook Vol.4 1979 p.5
UN, New York, p.195

(71) op. cit. pp. 194-5

(72) Nuclear Fuel, 28 April, 1980 p.9

(73) Nuclear Fuel, 9 June, 1980 p.2

(74) NPT/CONF.11/C.11/SR.8 p.303

(75) NPT/CONF.11/C.11/SR.7 p.296

(76) Nuclear Fuel, 23 June, 1980 p.12

(77) Interview


(79) Nuclear Fuel, 9 June, 1980 p.3

(80) Nuclear Fuel, 7 July, 1980

(81) IAEA, Annual Report 1980, p.5 para 19

(82) see footnote 3 and chapter 9 on the 1980 NPTRC

UN, New York p.228.

(84) Nuclear Fuel, 1 April, 1980 p.4, CAS mandate outlined in Board of Governors documents GOV/ 1997 and
Gov/OR.553 (a) ways and means by which suppliers of nuclear materials, equipment and technology and fuel cycle services could be assured on a more predictable and long term basis in accordance with mutually acceptable considerations of non-proliferation; and (b) The Agency's role and responsibilities in relation to that aim.

(85) see chapter 11

(86) IAEA, Documents GC (XXV)/OR 228 - 237.

1970s Simpson notes that, "... non-proliferation policies have become nuclear trade policies, rather than the other way round".

CAS held three meetings in 1981: 2-4 March, 15-17 June, 9-11 November. Two sessions were held in 1982.

(89) Michael Wilmshurst, UK Rep. to IAEA, notes that CAS sought to achieve consensus on a number of interconnected problems:
1. Can standardised and mutually acceptable non-proliferation conditions including questions of prior consent, be decided so that nuclear trade can flow free from the risk of disruption by the introduction of new conditions from time to time.
2. If so, can consumer countries be given some degree of assurance, by back up or international stockpile mechanisms, that if their supplies are interrupted for reasons other than non-fulfilment of mutually agreed non-proliferation conditions will be made good, at least temporarily?
3) If there are standardised conditions of non-proliferation to which consumer countries are expected to conform, should these not also be standardised conditions of supply, to be applied to supplier countries and verified in some way.
Reforming the Non-Proliferation system in the 1980s, Simpson and Grew op. cit. pp.155-6

(90) IAEA, Annual Report, 1982 p.11 paras. 34,35,36

(91) Nucleonics Week, 11 September, 1980 p.3, Wilmshurst op.cit. p.156

(92) R. Boardman, J.F. Keeley, Nuclear Exports and World Politics. Policy and Regime, MacMillan, London 1983 pp.110 - 7; Wilmshurst op. cit. p.156, "But if nothing positive were to emerge from its work the Committee serves a valuable role in sustaining the attempts to return to a consensus begun by INFCE."
CONCLUSION

(1) CAS/W.G. 1/W.P.2 Rev. 1 26 January, 1982 pp.10-11
Cas/S/4 W. p.4

(2) CAS op.cit. p.19

(3) Sir John Hill, The Driving Forces of Proliferation. Arms Control The Journal of Arms Control and Disarmament, Vol.1. No.1. May, 1980 pp61 - 2; Atom 289, November 1980 p.299; Interview; Dr. Ned Franklin has noted, "that the British, Canadian and indeed the French and Russian developments subsequently were classic examples of the inpracticability of preventing proliferation by the withholding of technology.... even as secretiveness on the part of the US had in those days had been unsuccessful and merely irritating to us, so it was and would be if we pursued the same line with the new developing nations of the world."
A personal view of the Nuclear Proliferation Problem. Journal of the Institute of Nuclear Engineers Vol.20. No.1. 1979 p.9; Interview
Dr. Donald Avery stated at a conference on Nuclear Power held in New Orleans and organised by the American Nuclear Society that, "There is no way by which current nuclear nations can prevent others from using this energy source by a policy of denial... We have no monopoly of human skills and we have certainly no monopoly of political will. What is needed is a stable international umbrella under which to conduct nuclear commerce. An absolute prerequisite for such commerce must be that governments accept that changes to such treaties can only be by mutual agreement to provide a length of time for any renegotiation which they may wish to institute."
Nuclear Fuel, 17 September 1979 p.14; Interview

(4) Hill, May 1980 op.cit., p.62


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6:        Plutonium Management
38:39      Dr. D.G. Avery (BNFL)
50:        Proliferation
51:        Plutonium safeguards, fast reactor
52:        Plutonium
67:        John Baker (CEGB) cross-examined by CND
75:        Proliferation
101:       Safeguards/Plutonium
131:       Martin Ince Town and Country Planning
          Association cross-examined (Exports)
143:       Plutonium Use Lord Silsoe (council to CEGB)
148:       Costs of PWR
150:       Rt. Hon. Tony Benn cross-examined (nuclear
decision making, role of government)
182:       Walter C. Patterson (Friends of the Earth)
205:       Dr. Kitty Little
243:       Atoms for Peace and Proliferation
244:       Plutonium Use
2333:      CND submission on secrecy
274:       Dr. Avery and Hugh Sturman (BNFL) cross-
           examined by CND (safeguards, plutonium
           use and proliferation)
275:       Dr. Avery (BNFL) proliferation
276:       Dr. Avery (Recalled) BNFL's case
283:       R.V. Hesketh, K.W.J. Barnham) (CND) cross
           examined proliferation and safeguards.
284:       R.V. Hesketh, K.W.J. Barnham, D. Lowry,
           cross-examined
295:       R.V. Hesketh, K.W.J. Barnham, R. Edwards
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