6 THE REACTOR THAT NEVER WAS: The Jervis Bay Project

6.1 Introduction

In the late 1950s the Australian Atomic Energy Commission's research establishment at Lucas Heights was a hive of activity to which researchers from around Australia as well as from overseas came to work. The establishment of AINSE meant that there was a continuous stream of young scientists and engineers who initially completed their researches at the site and sometimes would be recruited to work within the Commission itself. It was an intellectually stimulating place to be.

The cancellation of the HTGC reactor program meant that a number of Commission staff were disappointed and consequently with low morale, since their pet project was no more. The HTGC reactor project was barely cancelled when another reactor project took over. Despite the fact that Thomas Playford from South Australia was no longer pushing the power reactor cause in his state, the notion of an Australian power reactor had not died. It is unclear whether the push for an Australian power reactor came from the Commission through Baxter or whether it came from the politicians who ran the country. Nevertheless an Australian power reactor was still very much on the political and scientific agenda.

The purpose of the power reactor was another issue. The main purpose of nuclear power reactors is to produce electrical energy for distribution to the consumer. But nuclear power reactors can also produce plutonium. Some isotopes of plutonium are fissile and their production in a power reactor can be seen as an additional bonus; new fissile fuel is produced from uranium-238 which does not normally undergo fission. The problem with plutonium is that it is used in the production of nuclear weapons. For some governments a nuclear reactor which can produce substantial quantities of plutonium is an asset for their defence needs. Plutonium is also the predominant fuel used in a fast breeder power reactor which, in the late 1960s and early 1970s, was seen as the ultimate energy source. For every plutonium atom which undergoes fission more than one uranium atom is converted to plutonium and, in theory at least, one produced more fuel than was originally used. This was an engineer's dream; the production of new fuel from the 'burning' of old fuel. The question now appears, was a reactor required to produce electricity, to produce plutonium for weapons or to produce plutonium for breeder reactors? Further, is it possible to combine these aims?

This new power reactor project became known as the Jervis Bay Project and can be regarded as both the Commission's culmination and the beginnings of its decline. At first the Commission hoped to develop a locally-designed power reactor but later the project became the proposed purchase of a power reactor on a 'turn key' purchase agreement from a foreign manufacturer. This nuclear power reactor would be owned and operated by the Commonwealth Government (essentially operated by the AAEC). The Commonwealth would then sell the heat energy to the New South Wales Electricity Commission which was responsible for producing electricity. This electricity was ultimately to be fed into the state electricity grid. The project received its name when it was decided to build this reactor on Commonwealth-owned land at Jervis Bay.

The Jervis Bay project began in the heady days of the Beryllia Project in the early 1960s and concluded in 1971 with the election of a new Prime Minister, William McMahon (1908 – 1988). William McMahon, as Treasurer, had always opposed the Jervis Bay Project and now as Prime Minister saw to it that the project was cancelled.

Australian politics went through some remarkable changes during this period. The Liberal Party may have remained in power during the period from the time that Menzies brought it a victory in 1949 through to the end of 1972, but Australia had four Liberal Prime Ministers and one Country Party Prime Minister in the period 1966 –1970; of these one retired, one disappeared presumed drowned, and one cast the chairman's vote against himself. The political stability of the Menzies years was at an end and Australian politics became more colourful again. This period also marked Australia's increased commitment to the military engagement in Vietnam and a renewed sense that Australia required some form of advanced military defence capability.

The Prime Ministers and politicians during this period were again looking at Australia's nuclear defence capabilities. References in Cabinet documents suggest that defence requirements influenced the Jervis Bay Project; these influences were known to only a handful of politicians, bureaucrats, and one scientist, Sir Philip Baxter. The Commission scientists involved in the Jervis Bay Project believed they were working toward the introduction of a nuclear power generating reactor. The only member of the Commission who made any statements related to the production of plutonium was the Commission's Chairman, Sir Philip Baxter, and his statements suggest that the production of plutonium for weapons was not part of the Commission's brief. As far as can be determined, no other member of the Commission was aware that such discussions with government were taking place let alone taking part in them. The discrepancy in the two different views came to a head when the selection of tenders for the project was made. The Commission scientists chose the 'wrong' reactor. They chose a reactor which could efficiently produce power but they were supposed to choose one that would produce plutonium for weapons.

The structure of the AAEC in the period in question remained stable with few changes in senior personnel. The research into the development of this power reactor focused not only on developing a nuclear reactor for Australia and the additional training required for such an undertaking but also included research into methods of isotope separation and fuel fabrication. The need for uranium also came to the fore, this time for use locally rather than as an export commodity. The work in enrichment techniques and isotope separation was developed but the need to enrich uranium for use in a power reactor was not ultimately required. Finally, the reactor was never built, but the story about its inception, its development and its demise are significant to both the Commission and as a cautionary tale to all Australian scientists.

The teamwork and research activities during this period again demonstrated beyond doubt that Australia could have achieved a position amongst the leaders in nuclear science had the politicians decided to support the scientists in their work. Scientists engaged in 'big science' are so utterly dependent on governmental financial support that when this support is taken away the project collapses. This is essentially what happened to the Jervis Bay project; what had started as an scheme for national development lost all its financing at the whim of a new Prime Minister.

The story of this project is best told from two perspectives: the governmental or political perspective and the scientific perspective. The machinations of government provided the funding for this project and, equally, changes in the governmental attitudes, led to its cancellation. The scientists at Lucas Heights worked on a project which, despite all their efforts, was cancelled. Many of them had no idea why this occurred, which only added to their confusion. In trying to tell this story from the two perspectives, some overlap and repetition will inevitably occur.

6.2 Political Background

The sense that Australia was to plunge into yet another major armed conflict was the driving force behind much of Australian politics in the 1950s and 1960s. Menzies utilised this fear and effectively assured himself of a number of a election victories. Robert Gordon Menzies had been Prime Minister of Australia since 1949 when he defeated the incumbent Ben Chifley. Menzies had, as previously discussed, carried out many of Chifley's initiatives, most of which were completed in the period that Menzies was Prime Minister.

Menzies also managed to keep the Australian military machine well primed with excursions into a number of minor conflicts which seemed to define the period of the Cold War. In 1951 the Korean crisis had resulted in Australian troops being deployed as part of a United Nations action to prevent South Korea from being taken over by the Communist North. When this crisis had died down and a ceasefire agreed in 1953, the Australian troops were brought home. Australia again sent out the military to another nation which was suffering from a Communist insurgence: this engagement was called the Malayan emergency. This time Australia was supporting Britain which was simply protecting one of its colonies which was on the threshold of independence. Australia's involvement in this began in 1950 when the Australian Air Force assisted the British, later to be joined by ground troops in 1955. The emergency lasted until 1960 but it took another three years before all the Australian troops were brought home[1].

Another war was just around the corner. Australia sent a small contingent of military advisers to South Vietnam in 1962 and in 1965 a contingent of Australian troops was deployed to South Vietnam, again to fight the Communist threat[2]. The Menzies years were dominated by the Communist Revolution in China and an assumed threat from the North. One could be forgiven for thinking that it was not unlike the threat of the invading 'yellow hordes' that dominated the Australian political psyche in the late nineteenth century, but this time the hordes were also Communists thus managing to scare refugee migrants from Eastern Europe and the Australian populace in general. This tactic allowed Menzies to win a number of elections in which the Communist threat and its infiltration of the Trade Union movement made voting for the Labor Opposition an unpopular choice for certain voters.

It was the threat of war and the preparation for this threat that marked the Menzies years. Australia was always on the alert; from 1950 Australian troops were virtually constantly involved in military operations. It was this feeling of threat and war which drove many aspects of Australian life. Menzies had achieved an outstanding record as Prime Minister, in his two terms of office, the first from 1939 to 1941 and the second from 1949 to 1966, he had managed to involved Australia in four wars; the Second World War, Korea, Malaya and Vietnam, more wars than any other Prime Minister since Federation.

Menzies retired in January 1966 and was replaced by Harold Holt (1908-67). Holt had been a member of parliament since 1939 and he had been a minister under Menzies both before and after the Second World War. Holt maintained the support for the Vietnam War and was noted as the Prime Minister who was prepared to follow the US on any military excursion with the cry 'All the way with LBJ'[3]. This period coincided with an escalation in the US and

Australian military involvement in Vietnam, which included the use of chemical defoliants and talk of using nuclear weapons against what was effectively a guerrilla army operating out of the jungle.

Holt also followed Menzies in many other policy areas including nuclear energy. It was against this background that Holt's brief period as Prime Minister had an impact on the AAEC. Early in Holt's leadership, Australia, through the AAEC, changed its agreement with the US on the export of uranium. The Commission, in its Annual Report for 1967 noted that '*a tripartite agreement between Australia, USA and the International Atomic Energy Agency, transferred to the Agency the responsibility for administering safeguards under the USA/Australia bilateral agreement. These safeguards ... are designed to prevent diversion to military use of materials supplied for peaceful purposes*'[4].

Against this political background other social affects begin to affect the Commission. The area around the AAEC Lucas Heights research establishment which had been part of a 'Green Belt' around Sydney was now being threatened with housing development. As was discussed in Chapter 4, the area around Lucas Heights had been subject to a three-mile exclusion zone which effectively ensured that there would be no human habitation in the area immediately around the reactor. In 1967 the NSW State Planning Authority was under pressure to allow intensive urban development in the area around the Lucas Heights site. The only solution available was for the exclusion zone to be limited to one mile around the reactor and for the Commonwealth Government to purchase this land to ensure the continued existence of this zone. This land was duly purchased and is now clearly visible as the bushland surrounding the research establishment which itself is surrounded by the sprawling suburban developments of Menai and other parts of the Sutherland Shire[5]. See Figure 6-1 below.

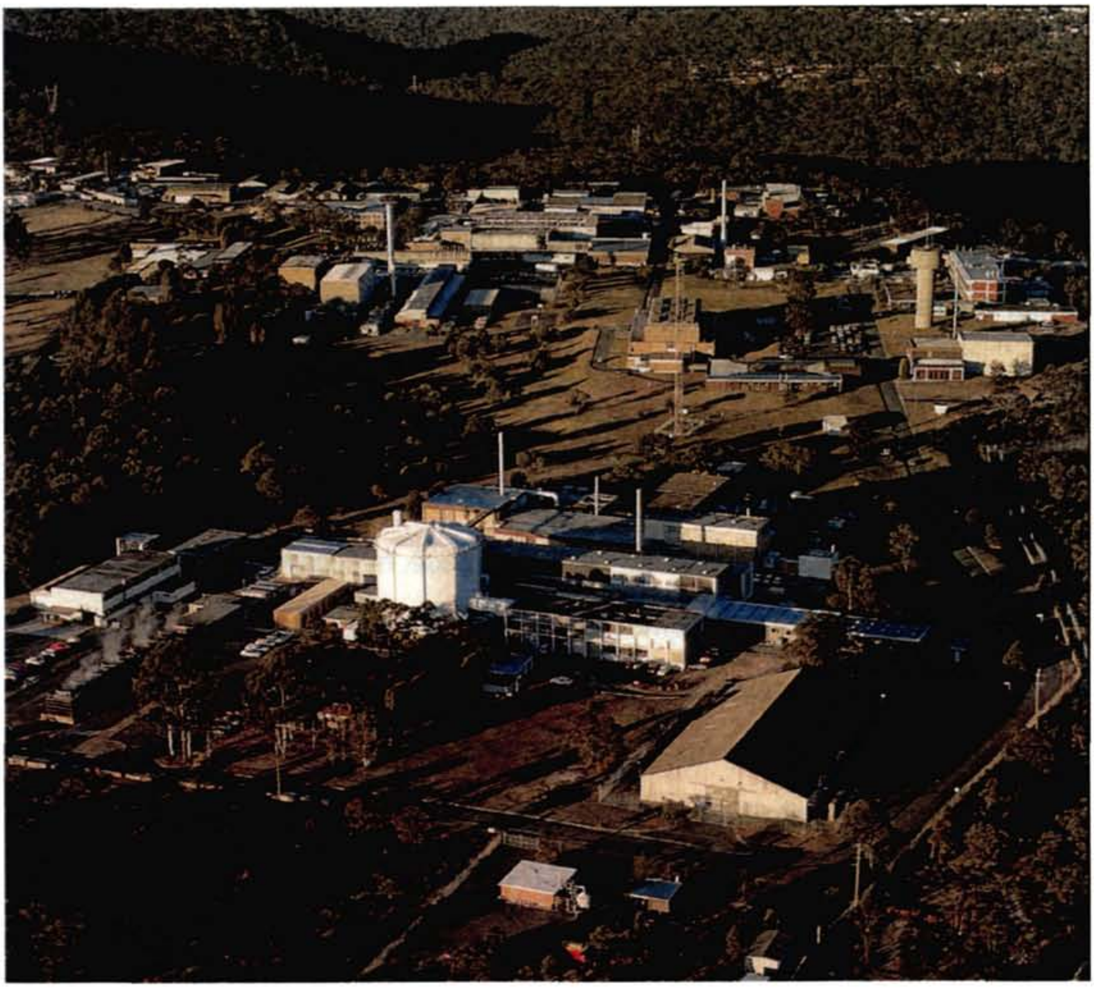

Figure 6-1 Lucas Heights Research Establishment
Courtesy of ANSTO

Another issue involving the AAEC was that of the possible export of uranium oxide from the Mary Kathleen mine[lxi] to Britain. The issue was twofold. Firstly the British request was for uranium oxide which was not subject to 'safeguards' and second was the decision to export the uranium oxide against the spirit of an existing government policy. The IAEA had by 1967 established a safeguards agreement between member states that any uranium exported from a producer nation to another nation was to used for peaceful purposes.

[lxi] The Mary Kathleen uranium mine was discussed in chapter 3.

The safeguard protocol included an agreement by both nations as to the end use of the uranium and the possible inspection of the material being exported and the facilities in which it was produced. The British were asking Australia to provide uranium for possible use in nuclear weapons.

This request, if it had been granted, required an amendment to an earlier Cabinet decision on uranium conservation and exploration. This earlier policy had been made public on the 10th April 1967, barely a month before the Mary Kathleen request was received. The press statement made by David Fairbairn, the Minister for National Development, stated that '*the Commonwealth Government proposes to conserve known uranium resources for future essential needs in Australia whilst encouraging exploration to establish new uranium reserves... in future companies would be entitled to export uranium under conditions which take into account the size of the uranium ore deposits and/or the date of their discovery*'[6]. The conditions set out for uranium export were now part of Government Policy.

The request from Britain to purchase Mary Kathleen uranium was contrary to the then existing Government Policy on the export of uranium ores. Baxter responded, on behalf of the AAEC, to the Government's request to consider a possible change in export policy to allow for the export of Mary Kathleen uranium. In his response, Baxter stated '*the presently agreed policy should not be amended in the case of Mary Kathleen Uranium Ltd, and that the request for export should be refused*'[7]. Baxter then suggested that if the Government should decide to allow this export then a number of conditions should be placed on Britain and agreed to before any such export took place. These conditions were to '*safeguard ... Australia's nuclear interests in the future*'[8] and this included an agreement from the British Government that it would '*in the future supply Australia with nuclear materials, equipment and* *facilities without requiring the attachment of International Atomic Energy Agency safeguards to such supplies*[9]. In short, if Britain wanted to buy raw materials from Australia without safeguards then Australia wanted to buy other items from Britain without safeguards!

Baxter included an attachment which had been used in the submission to the uranium policy that had been announced on the 10th April 1967 and had been agreed to in Cabinet on 14th March. This attachment clearly stated that, as far as the Commission was concerned, nuclear power was going to be introduced into Australia in the foreseeable future (ie by 1980 at the latest). He further stated that this industry was '*not only to include the construction and operation of nuclear power stations, but a number of supporting industries concerned with the production of components, fuels, the treating of spent fuels and related operations. These industries will have export potential*'[10].

This particular document also included a statement which could lead one to think that the Australian Government, under Harold Holt as Prime Minister, was considering the production of nuclear weapons. '*In a recent discussion, you*' (possibly Fairbairn, since the note is addressed to the Minister) '*suggested that we need only be concerned with enough uranium to support the production of a limited number of atom bombs, and need not concern ourselves with supplies for the States for power production.*' Baxter in the next sentence states what he considers to be the Commission's position on this matter '*Weapon requirements is a matter outside the Commission's responsibilities.*' The paragraph concludes '*If it was proposed to build reactors specifically for the production of Plutonium for weapons (which is different from producing plutonium in a reactor operated to produce electricity economically) – the former method of operation would be extremely expensive. We believe that the only reasonable way for Australia to produce* *nuclear weapons, if that should become the Government's policy, would be as a by-product of an economic power project conducted in association with a generating authority. For this, a quantity of uranium equal to our present reserves would be necessary'*[11].

Baxter's assertion that weapons requirements were outside the Commission's responsibilities is clearly incorrect. The Atomic Energy Act 1953 quite clearly stated that one of the functions of the Commission was to ensure '*the provision of ...uranium or atomic energy for the defence of the Commonwealth'*. Baxter's comments to his Minister lead to further questions. Was Baxter aware of this section of the Act? Did he really attempt to stop the Commission from getting involved in plutonium research? Further, did the Holt Government want to build nuclear weapons? These questions will remain unanswered, but the fact that the Commission was busily working towards the development of nuclear power stations which could produce plutonium may give a hint to what may have been happening behind the closed doors of defence and national security.

Keith Alder had a long and close working relationship with Baxter, and according to Alder, Baxter was a '*most misunderstood man'*. Alder relates how Baxter had '*confided ... on several occasions that he* (Baxter) *viewed atomic weapons with horror but he did not want Australia to be without the ability to make them if necessary... He did not want to go down in history as the one who gave Australia the bomb. He did want to go down in history as the man who took Australia into the nuclear age by the introduction of nuclear power '*[12]. Alder's comments indicate that Baxter's views were not so dissimilar to those of Chifley who wanted Australian industry to be developed so that, if necessary, conversion for defence purposes could be achieved relatively easily.

Holt's influence on Australian politics would not last for long. In late 1967 he went for a swim in the treacherous surf at Cheviot Beach near Portsea, Victoria and disappeared. It was presumed that he drowned but his body was never recovered. A caretaker Prime Minister, John McEwan (1900-80), now governed the country. McEwan was leader of the Country Party which formed a coalition government with the Liberal Party and under the coalition agreement the leader of the minor party was the Deputy Prime Minister. It was McEwan who now affected the course of Australian history. By using his veto against William McMahon, John Gorton (1911-2002) was elected as the new Prime Minister of Australia[13].

John Gorton had served as a pilot in the RAAF during the Second World War and was elected as a Liberal Senator for Victoria in the 1949 General Election that brought the Liberal party into office. He held a number of minor ministerial positions in the Menzies Government until he was elected Prime Minister, as a compromise candidate and with the initial support of John McEwan. Gorton was the first Senator to become Prime Minister and eventually left the Senate and was elected to represent the seat held by the late Harold Holt. The new Prime Minister was the complete antithesis of his Liberal predecessors. Gorton had a gregarious and down-to-earth image despite being Oxford educated. He was also a reformer and had a sense of Australian nationalism which was manifested in a style that was not deferential to Australia's powerful allies[14]. Gorton had a vision, similar to that demonstrated by Chifley, of what Australia could achieve as a nation and nuclear power was part of this. John Gorton embraced the notion of a nuclear power reactor for Australia. He had been an early supporter of nuclear energy and as early as 1957 had argued that Australia should be exporting metallic uranium rather than uranium oxide[15]. In fact, nuclear power was again seen as a possible source of cheap electricity.

The decisions concerning the AAEC were all in relation to the establishment of a nuclear power plant which would be owned by the Commonwealth Government but which would sell the heat to a state electricity production authority. Specifically, the Commonwealth Government through the AAEC would operate the reactor and the state electricity commission would operate the electrical generating plant. It was under the Gorton Government that the Jervis Bay project was conceived, then developed and grew.

The international stage now produced a new factor for Australia to consider: the Nuclear Non-Proliferation Treaty and the adoption of its safeguard provisions. This treaty was sponsored jointly by both the USA and the USSR in 1968 and in essence limited the dissemination of nuclear material and knowledge to a select group within the existing nuclear club. Detailed discussion of this treaty is beyond the scope of this thesis but some of its implications are relevant. The treaty defined 'nuclear weapons powers' as those nations which had exploded or tested a nuclear device before 1st January 1967 (these nations were USA, USSR, Britain, France and China). The treaty stated that those nuclear powers were not to transfer nuclear weapons or explosive devices to any country outside this small group[16]. Furthermore, the treaty expected that non-nuclear nations would not accept any such device, as part of the treaty's safeguards requirements. This of course had profound implications for Australia, a non-nuclear nation with vast amounts of uranium ore.

Australia initially refused to sign the Treaty, '*giving as its reasons ... that the Treaty might not prove to be effective; that Australia's future security might be* *jeopardised by it; and more ambiguously, that the safeguard inspection provisions might impede Australia's civil nuclear development'*[17]. Baxter supported the Government's stance on the issue. He believed that the Treaty was "*an incomplete and potentially ineffective instrument' sustaining the nuclear weapons capacity of the 'have' nations without providing sure protection for the 'have nots"*[18]. Baxter's views on the weapons issue at that time were well publicised. In March 1968 he is quoted as saying '*Australia should expand and protect those industries on which defence ultimately rests and so equip ourselves to defend our lives and country with the most sophisticated and effective weapons that man can devise – with no types excluded*[19].

The Gorton government was reluctant to sign the treaty '*until it was convinced it was in the country's interests to do so*[20] and '*the Nuclear Non-Proliferation Treaty would not be signed until the government thought it would not jeopardise Australia's peaceful use of nuclear energy*[21]. Gorton wanted to protect Australian interests as far as nuclear energy and the nuclear fuel cycle was concerned. But not all members of his Cabinet agreed, specifically William McMahon was very much in favour of signing the Treaty.

The earlier discussions on Australia producing its own plutonium now had an added significance. If Australia signed and ratified the Nuclear Non-Proliferation Treaty[lxii] Australia could never gain access to the technology required to develop a nuclear defence capability. On the other hand Australia had uranium reserves which could be used for both civil and defence purposes. Australia was also involved in a military action in Vietnam. Moyal

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[lxii] Australia finally agreed to sign the Non-Proliferation Treaty in February 1970 but did not ratify it until the 23rd January 1973, just over a month after the Australian Labor Party was returned to Government for the first time since 1949. The Safeguards Agreement would come into force eighteen months later.

quoted William McMahon as stating '*there was always a residue of thought in Government ... which said that if we could get to the stage of producing nuclear power ... and wouldn't be able to get assistance from the other countries to produce nuclear weapons, it was urged on us that we would be able to achieve the threshold between production of plutonium for a civil and military operational use*[22].

The Gorton Cabinet met on the 5th of December 1968 for the first of a number of discussions leading up to the Jervis Bay Project. Two submissions were discussed. The first dealt with the Commonwealth's role in the development of nuclear power in Australia. This submission was prepared by the AAEC and was jointly presented by Fairbairn as the minister responsible for the Commission and McMahon who was Treasurer. The issue of defence and control of fissile fuels comes yet again to the fore; '*a national fuel policy would allow complete control of fissile materials relevant to defence; it would also confer the ability to accumulate and plan the most economic use of an independent source of plutonium for the advanced and economic reactors, including the fast breeder reactors*[23]. The Commission again stated its preferred position '*it is important to build only one type of nuclear power station for a reasonable period of years*[24]. Treasury, through McMahon, opposed the expenditure for such a reactor.

The Cabinet decided that '*the Commonwealth should take the initiative with the states in securing adoption of a national fuel policy*' and that in such a policy '*Australia should seek to avoid dependence on fuel from overseas and that reactors should be able to be fuelled from indigenous fuel supply*[25].

The second submission involved a proposal for a Joint Commonwealth-State nuclear power station. This was the first time such a concept had been discussed. Previously, the Commonwealth was supporting the development of a power reactor which the individual states would operate; the states in question were Victoria and NSW. The basis of the submission was essentially that since nuclear power plants use material and produce material which can be used for weapons, they require a network of support industries which deal with potentially hazardous material and, since there are international conventions set up on the protocols associated with nuclear power production, the Commonwealth should control the nuclear part of such a plant. The submission suggested that '*the station would employ a natural uranium heavy water moderated reactor designed to provide a net electrical output of 500MW*'[26]. Plutonium again, is mentioned, this time as a comment as to its nett worth '*during its normal course of operation, the reactor would produce approximately 160kg of fissile plutonium annually as a by-product in the spent fuel*'[27].

It is unclear what the purpose of this plutonium would be. There are two theories; one was that the plutonium would be essential to the next generation of nuclear power reactors, the fast breeder reactors, the other was that Australia should be able to produce nuclear weapons for defence purposes without being reliant on the support of other nations. One could question the wisdom of each of these theories. Fast breeder reactors were still very much an experimental technology, and the thought that Australia should produce nuclear weapons for defence purposes would have been, in the long term, an expensive and non-trivial exercise. Obtaining plutonium from spent cells is a chemically messy and hazardous undertaking requiring large plants which require shielding from radiation.

Cabinet, at this December meeting, '*considered that at this stage it did not need to make a decision whether or not it should become involved in the* *construction of a nuclear-powered station*[28]. Cabinet did, however decide to undertake discussions with the two states concerned and to allow a greater exploration of the issues.

The major problem associated with the power reactor was that of ownership. It has already been discussed that the power reactor would be wholly owned by the Commonwealth and hence needed to be sited on Commonwealth land. The only land owned by the Commonwealth Government was the land that had been set aside in the immediate vicinity of Canberra; ie the Australian Capital Territory. The other relatively small land holdings that the Commonwealth held were those on which the different armed services had built their bases, such as Pt Cook in Victoria and Jervis Bay in NSW. The search was now made to discover which would be the best location. One of the criteria for siting the power reactor was that is should be placed close to the electricity grid that fed from the Snowy Mountains Hydro-electric Scheme. The ACT and Jervis Bay were the best possible sites for this purpose.

Cabinet met again in September 1969 to discuss the new submissions relating to the Commonwealth owned nuclear power station. Discussions had followed between the Commonwealth Government, the NSW Electricity Commission and the AAEC, with the result that now the submission indicated that the Commonwealth Government, through the AAEC, should own and run a nuclear power reactor and that the NSW Electricity Commission would operate the power station. Cabinet decided to approve, in principle '*the construction of a 500 megawatt nuclear power station on Commonwealth territory*'[29]. This decision required the approval of a number of Commonwealth Government departments and the NSW State Government.

The location of the power station now became relevant. According to Moyal, a total of fifteen sites had been considered including sites in South Australia, the Snowy River region and others in the ACT[30]. The NSW Electricity Commission had a long term view of where any new nuclear power stations should be located. They included four sites within NSW; Spencer on the Hawkesbury River north west of Sydney, the Jindabyne Reservoir in the Snowy Mountains, Bass Point south of Wollongong and Jervis Bay North. Three additional sites on Commonwealth land were also considered; Murrumbidgee River at Cotter in the ACT, Murrumbidgee River at Uriarra in the ACT and Jervis Bay South. The sites in NSW '*offered no technical advantages compared with others in the Commonwealth territory. For this reason, and with the agreement of the Electricity Commission of NSW, studies of the New South Wales sites were discontinued*'[31].

The three remaining sites were studied more closely. Issues such as safety and the public perception of safety were specifically considered: '*until the public becomes accustomed to the operation of nuclear stations, it would be wise not to place Australia's first station on sites involving inland waterways. This favours the Jervis Bay site where no such problems arise*'[32]. Hence the two sites in the ACT were excluded from further consideration. Many aspects of the sites were considered before the final choice had been made and these aspects included; '*geology and foundation conditions, hydrology, ... site access and development, transport, available cooling water and reliability of supply, safety aspects, transmission lines and proximity of load centres*'[33]. Further work from '*geophysical seismic surveys indicated strong sandstone, suitable for foundations under weathered rock*'[34] and '*study of tides, currents and winds had confirmed that cooling water could be easily drawn in and there would be rapid dispersal of it later*'[35]. Jervis Bay had a slight economic advantage over other sites[36].

There were two possible locations on the southern part of Jervis Bay that were considered: Scottish Rocks and Murray's Beach. The Department of Defence did not want the reactor in the southern part of Jervis Bay since it would be in close proximity to the airfield that served the Naval Base but it did seem to approve the siting of the reactor at Murray's Beach in Jervis Bay with some reservations: '*even site 1A (Murray's Beach) is less than ideal ... possible interference with the flight path associated with the existing Naval air field by the Scottish Rocks site causes the Navy to prefer Murray's Beach and the Department of the Interior would also favour the Murray's Beach site*'[37]. It appeared that the Murray's Beach site was ideal but it was noted in the submission that '*two important and expanding facilities ... in a comparatively small area could give rise in the longer term to difficulties which cannot at present be foreseen. There could also be some problems of public presentation*'[38]. A nuclear power reactor located adjacent to a naval base could cause some concern in the public's mind as to the exact nature of the enterprise. See the location map in Figure 6-2.

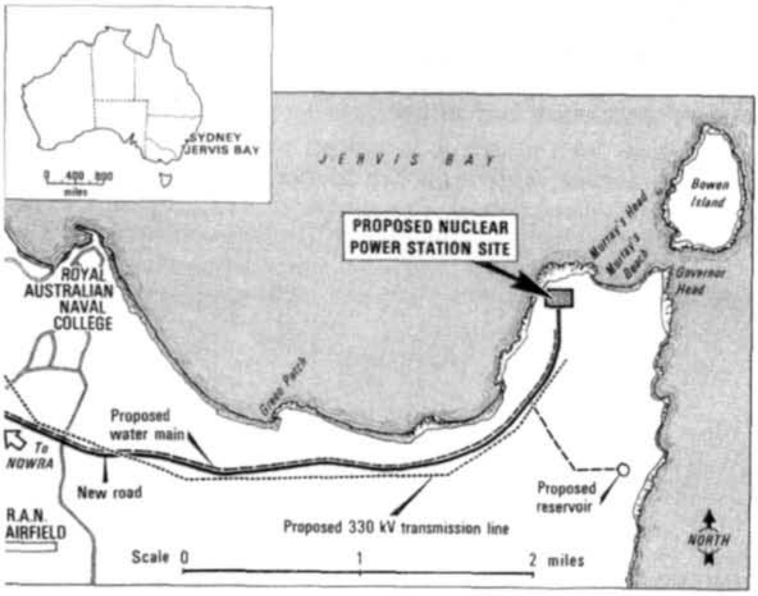

Figure 6-2 Jervis Bay Site

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Not everyone agreed to the siting of the power reactor or even whether Australia should have a power reactor at all. In a submission to Cabinet made by William McMahon on 8th September 1969 he stated all his reasons against the building and siting of the power reactor at Jervis Bay[39]. This submission advised against the enterprise primarily on economic grounds, questioning many of the premises on which the decision to embark on the nuclear power station project was based. He also questioned the nature of the agreement between the NSW Electricity Commission and the Commonwealth Government. He finally suggested the establishment of an interdepartmental committee to review all aspects of these proposals[40].

The Cabinet did indeed establish the Interdepartmental Committee that Treasury had suggested. But it also gave approval '*to proceed to the stage of calling for tenders for construction of the nuclear station*'[41] and approved increased financing of the AAEC to allow for the employment of an expanded workforce and the deployment of existing staff who were to be involved in the power station project[42]. The Jervis Bay project was born.

The announcement of the birth of this project was not done to a fanfare of trumpets, as had been done with the developments of the 1950s. Cabinet decided that '*the announcement should come as part of a statement of forward policy and within that statement, under a general heading of power development, and as to substance, that it should indicate that the Commonwealth had taken its decision in principle and that it would be proceeding with the project during the next three years*'[43].

The government effectively hid the new project under a pile of other energy matters. The question remains as to why. If it were a power-only project were not the voters entitled to know? If it was part of a defence agenda, why make any announcement at all? Did a new reactor project need to be kept hidden from the public because of environmental concerns or was it simply that most of the members of Cabinet did not support the project at all? Regardless of the answers to these questions, there was never any public debate on the issue and the Commission carried out its work as before.

The notion that Australia should control the uranium fuel cycle was proposed in a submission to Cabinet. Each year the Commission officers prepared a submission to Treasury for approval of their annual expenditure, but for more long-term projects or amendments to existing projects a separate submission was prepared for Cabinet approval. The AAEC placed before Cabinet a submission entitled 'Nuclear Development in Australia' in which there is a request to amend Cabinet Decision 353 of 18th May 1967 '*to take account of developments which will result from decisions of Cabinet to construct Australia's first nuclear power station, and to base nuclear power generation in Australia on the use of indigenous fuel*'[44]. The Commission saw the Jervis Bay power reactor as the first of many and hence wanted to ensure that

Australian industry would be able to support this growth in a new technology. More importantly perhaps, the Commission wanted to ensure the funding of its new research directions, specifically '*the Commission has established the Nuclear Development Division to undertake ... preliminary work in close association with the Research Establishment'*. The areas of specific interest were:-

'(i) *the manufacture of nuclear fuels*

(ii) the processing of spent nuclear fuels and the recovery of depleted uranium and of plutonium, together with the safe disposal of radioactive wastes

(iii) the provision of a new research reactor

(iv) the production of enriched uranium

(v) the production of heavy water'[45].

The submission then outlined in greater detail the nature of the work that was to be carried out in these areas. The development of the nuclear fuel production plant was recommended '*as soon as the type of power station to be built at Jervis Bay is determined*'[46]. It was noted that '*the spent fuel from nuclear power stations contains plutonium, depleted uranium and radioactive fission product wastes. These fuels may be treated by a chemical process ... the recovered plutonium and depleted uranium are valuable and will be used later in a fast breeder reactor program. The radioactive wastes must be separated and stored in a safe and permanent manner so that they do not pollute the environment*'[47].

The idea for a new research reactor now arose. HIFAR had served the Commission for ten years by then and the Commission believed that it needed a new research reactor since '*it is considered that twenty years should be assumed as the final life*'[48] of the reactor and that it would take at least five years to plan and build a replacement reactor. The Commission argued that MOATA was no real substitute for HIFAR, that '*the whole of radio-isotope production depends on it*', that its '*facilities are almost saturated*' and that the '*extensive university programs are based on the facilities it provides which are not available elsewhere in Australia*'[49]. One wonders what Baxter's thoughts may have been had he known that HIFAR would be almost forty years old before the government finally agreed to replace it and that this decision would be dogged for a number of years by opposition from community and environmental groups.

The submission noted that the technology behind enrichment processes was classified because '*highly enriched uranium being the normal trigger for a hydrogen bomb*'[50]. The submission proceeded to describe the different enrichment processes including the Commission's own progress in this area. The need for a heavy water production facilities was partly justified by the use of heavy water reactors which were '*highly efficient in their use of neutrons, which result in a greater production of plutonium –a valuable by-product of power generation – than in other systems*'[51]. The plutonium issue again raised its head, this time it was the Gorton Government to which this was addressed. The question still goes unanswered, was there a government desire to produce plutonium for military purposes? Was this the selling point that Baxter used to obtain funding for his reactors, none of which ever materialised?

The Commission at this time was relatively stable but there was still a turn over of members of the Commission. When '*the term of office of Sir Leslie Martin expired 30th April 1968*', Martin did not want to be reappointed and later '*Mr Bernard Francis Dargan resigned from 31st May 1968*'. Two new Commissioners were appointed '*Dr Robert George Ward, Director of Research, Broken Hill Proprietary was appointed Deputy Chairman of the*

Commission and Keith Alder ... was appointed as Member of the Commission'[52]. The following year the AAEC, noted that '*the Commission records with deep regret the deaths ... of two former Commissioners- Sir Jack Stevens and Sir Harold Raggatt*'[53]. '*Sir Jack Stevens died on 20th May 1969*' and '*Sir Harold Raggatt died on 2nd November 1968*'[54]. In October 1969 Boswell resigned as a Commissioner to take up a post as Australia's High Commissioner in London and L.F.Batt was appointed to fill the vacancy[55].

Sir Philip Baxter retired as Vice-Chancellor of the University of NSW and '*in June 1969, the former part-time Chairman, Sir Philip Baxter was appointed to the position full-time, with effect from 1st July*'[56]. Baxter could now concentrate his efforts on the Commission and, more importantly, could be available to take up a new post, that of Chairman of the IAEA Board of Governors. He was elected to this position in September 1969 and was to remain in office for the next twelve months[57]. The process for the election as Chairman of the IAEA Board of Governors was rather lengthy, in that a candidate suitable to the major powers was required and the government of the nation from which the Chairman came was to meet his salary for the term of the appointment. Baxter was not the first Australian to serve as Chairman of the IAEA Board of Governors; as mentioned in Chapter 4, A.D.McKnight had also served a twelve month term as Chairman of the Board of Governors during 1960-1[58].

The Prime Minister in October 1969 announced '*that the Commonwealth Government would take Australia into the atomic age by beginning the construction of an atomic plant at Jervis Bay to generate electricity*'[59]. The opposition to the power reactor was noted but ignored and the project went ahead. Moyal also noted that there was no public hearing regarding the Jervis Bay site nor on any aspect of the power reactor project[60]. What concerned the AAEC and the Commonwealth Government was to negotiate with the

Electricity Commission of NSW the exact contract under which the reactor would operate and to determine the responsibilities of each partner in this project.

Changes in the makeup of the Gorton Ministry also brought changes to the Minister who was responsible for the AAEC; *'R.W.C.Swartz formerly Minister for Civil Aviation was appointed Minister for National Development on 20th November 1969. ... D.E.Fairbairn resigned as Minister on 13th November 1969'*[61]. Swartz was to remain the Minister responsible for the Commission until the Australian Labor Party won the 1972 general election.

The overall responsibility for the Jervis Bay project was to rest with the AAEC. The Commonwealth government would own and finance the construction of the reactor. A co-ordinating board would be established and would be responsible for the overall administration of the reactor and would ensure that the management of the reactor complied with all the standards and procedures developed for this type of power reactor. This board would be made up of a Chairman, nominated by the Commonwealth, two representatives from the AAEC and two representatives from the Electricity Commission of NSW. A chief executive officer would be appointed by the AAEC to run the power station but the NSW Electricity Commission would be responsible for the operation and maintenance of the power-generating part of the power station[62]. The Electricity Commission of NSW would own all the electrical power produced and would undertake to supply electricity to meet the present and future needs of the ACT. The nuclear fuel would be owned by the Commonwealth[63].

The AAEC worked on all aspects of the new power station. Aspects of the fuel cycle including fuel fabrication, enrichment and reprocessing of spent fuel were all considered. Reactor systems were also studied and compared. Staff had been allocated to the reactor project and a small restructuring of the research facility followed. On May 1st 1970, Cabinet again met to discuss the Jervis Bay project, this time they were concerned with the future control and operation of the Jervis Bay nuclear power station. The submission presented to Cabinet suggested that the nuclear part of the station '*should be operated for the Commonwealth by the AAEC*'. The remainder of the plant was to be operated by the Electricity Commission of NSW[64]. The Cabinet met again on 27th May to be informed by Swartz that '*he had reached agreement with the Government of NSW upon arrangements for the operational control of the station*' as had previously been set out[65].

Work on the reactor site was also progressing. By July 1970, the AAEC required more funds to establish '*a village in the area*' for the workmen who were involved with building the infrastructure at the reactor site. A road was needed, a water supply and a connection to the electricity grid were also required and later housing for the staff. Cabinet met again and approved the expenditure of the necessary funds[66]. The site at Jervis Bay on which the reactor was to be built was excavated to a reference level. The material that had been excavated was now used to build a two lane four mile long road to provide access into the site. '*Services such as water, electricity, telephone and sewerage were provided or preparations made to provide them*'[67]. It was noted that, by the beginning of 1971, twelve houses had been completed at the site to provide accommodation for those who were involved in the construction of the reactor[68] . See figure 6-3.

Figure 6-3 Jervis Bay Reactor Site

Plate 1 AAEC Annual Report 1971

Tenders were called and received (this will be discussed in more detail later in this chapter) and on 18th August 1970 the Cabinet met to review the tenders submitted. Cabinet resolved that the AAEC should continue the process in more detail with a select number of the tenderers: Atomic Energy of Canada for a heavy water reactor, the Nuclear Power Group from the UK for a steam generating heavy water reactor[lxiii], Kraftwerk Union from West Germany for a pressurised water reactor and Westinghouse Electric from the USA for a pressurised water reactor[69].

The Liberal Government was losing public support, specifically since conscripts were now being sent to fight in Vietnam. Gorton's position as Prime Minister was also becoming more tenuous within the Liberal Party organisation so when one of his Ministers, Malcolm Fraser (b 1930), resigned and refused to continue working with him, a leadership challenge resulted. William McMahon was his challenger and, when a vote was taken in the Party Room on 10th March 1971, the result was a tie between Gorton and

[lxiii] See Appendix 3

McMahon. Gorton used his casting vote as the Chairman in favour of McMahon[70]. McMahon was now Prime Minister and would remain in this position until the 1972 election when the Labor Party, under the leadership of Gough Whitlam, formed the first Labor Commonwealth Government since Chifley.

William McMahon had been Treasurer in the Menzies Government and like his Treasury bureaucrats opposed the allocation of funds for many of the expensive AAEC projects. McMahon's arguments were always based on the economics of the situation and it was quite apparent that he did not understand what was involved in the scientific and engineering development and research carried out by the Commission. In short, McMahon was a man more concerned with money than with nurturing Australia's scientists. One of the first decisions that he made as Prime Minister was to firstly place a twelve-month moratorium on the Jervis Bay Project and then subsequently to cancel it completely[lxiv]. An Australian nuclear power reactor never again appeared on the political stage.

What Baxter's private thoughts were concerning the suspension of the Jervis Bay project and the cessation of government interest in nuclear power, are not known. On 15th April 1972 Baxter retired from the Commission. He had been Chair of the Board of Governors of IAEA in 1969-70 and Australian Governor on the IAEA in 1957 and again from 1964-72. Baxter's retirement marked the end of an era in the Commission. The man who had been so intimately involved in the conception and development of the Commission was now no longer a part of it, but the Commission too was changing direction. R.W.Boswell was appointed the new Chair and returned to the AAEC[71].

[lxiv] This will be discussed in detail at the end of this chapter

6.3 A Home Grown Reactor?

This section will cover the same period as the previous section but the discussion will focus on these events from the position of the AAEC. Many of the events will be recalled and at times the material will appear repetitious. One could not understand why certain decisions were made within the Commission without having an understanding of the politics of the time. The scientific work carried out at the Commission was a complex series of events and hence is best treated as a separate section.

It is worthwhile to review the story of an Australian reactor as seen from the perspectives of the scientists and engineers who worked for the Commission. When the Commission was initially established, there was some desire to build locally designed and built power reactors in Australia. The first possible site was at Port Pirie, South Australia. Australian scientists were sent to Britain to be trained in nuclear science and engineering. When they returned home they brought with them a new research reactor, HIFAR. This reactor was a materials testing facility which was then put to work for other purposes; such as neutron diffraction and isotope production.

During this early period, until about 1966, a number of different reactor designs were considered and all eventually rejected. The last was the High Temperature Gas Cooled Reactor. The cessation of work on the High Temperature Gas Cooled Reactor which the Commission concluded was '*not as attractive for base-load power stations as previously expected*'[72], resulted in AAEC scientists exploring other types of reactor technology. Australian scientists still wanted, in principle, to produce a locally designed reactor for 'Australian conditions' or, failing that, to design and build a local version of a reactor system that had proved to be a successful from overseas experience. However, the innovative local product was still somehow deemed to be inferior and more expensive than a commercially produced product from overseas. This attitude, which was commonly held in the late 1960s, still holds true today when many Australian innovations are sold to overseas buyers because no one in Australia is prepared to develop, produce and support the local product. The Commission decided to study a number of different types of reactor systems in order to choose one that would best suit Australia's needs.

The AAEC had a group of scientists who effectively kept a 'watching brief' on overseas developments in nuclear energy. Consequently, the AAEC knew what the latest developments were in reactor technology. They knew what new ideas were being explored, what new types of reactors were being built and which type of reactors failed to produce the expected outcomes. The reactor industry had by the late 1960s stabilised to some extent and private firms and companies were developing reactors that could be sold to energy producers. Nuclear power-reactor technology was now a commodity which could be bought and sold. Many nations had, by now, incorporated nuclear energy production into their national grids and in some instances nuclear power was taking over from energy production using fossil fuels.

Work on reactor technology within the AAEC continued without interruption but now was transferred to '*a technical and economic assessment of a heavy water moderated, natural uranium fuelled reactor suitable for central power applications in Australia*'[73] . The Commission noted in its Annual Report of 1966 that overseas power authorities were standardising their systems to use one or two types of reactor. The following year, the Commission stated that

> *'in Australia, it seems evident that construction of several nuclear stations could be economically justified in the period 1975-80. The first step is crucial; the choice of the first reactor system could fix the pattern of Australian nuclear power development for the future ...great*

advantages to Australia would flow from a nuclear industry based on indigenous uranium supplies and not on imported fuel'[74].

The question arises as to why the Commission should start considering heavy water moderated reactors and how did the notion of using natural uranium come about? Reactor engineering from the early 1950s was one of applied experimentation. A variety of fuels, moderators and cooling systems were explored. This experimentation continued into the 1960s as new power reactors came on line and other prototype reactors were built, calibrated and assessed.

Heavy-water production plants were established in a number of locations including Canada and the US. The technology used in the production of heavy water was then in the commercial domain, having moved from the secret military area a decade earlier. It was now possible for nations to consider building their own heavy-water plants on a commercial basis and Australia was certainly considering such a move.

Natural uranium is referred to as being a fertile fuel which means that when it is bombarded by neutrons in a reactor, it is converted into plutonium-239. Plutonium-239 is a fissionable material and a fission reaction can be produced by this newly formed plutonium isotope. Fuel for reactors at this early stage still tended to be enriched uranium and this was the problem. The plants which produced commercial quantities of enriched uranium were essentially all in the US (France and the UK also had enrichment plants but they were initially established for military purposes[75]). In the words of the AAEC Annual Report of 1968 '*a number of countries have expressed considerable concern over a continuing dependence on the USA for enriched fuel supplies ... these countries are examining possible alternative means of supply and / or* *feasibility of employing reactors which will not require continuing supplies of enriched uranium'*[76]. This US monopoly of supply of such an essential resource was the cause for concern not only for Australia but for other countries wishing to produce nuclear power.

The Commission used its Annual Reports to state its intentions; *'While many different types of nuclear reactors are still being built or developed, some of the less promising concepts have been abandoned and this process can be expected to continue. In general, power authorities in the more advanced countries are standardising on one or two proven systems'*[77]. This statement reiterated Commission policy that it supported the introduction of one type of reactor system to be used throughout Australia. Further, *'heavy water moderated reactors have certain attractive features, such as ability to use natural uranium, low fuel cycle costs ... Accordingly, the Commission proposes as a matter of urgency to obtain expertise in this class of power system'*[78].

The Commission favoured the use of natural uranium, since Australia had large reserves of uranium and the use of natural uranium meant that Australia would not be dependent on the importation of fuel. The Commission changed its main research project by adding that it would prefer to use indigenous uranium in the fuel elements; *'the Commission's main research program has been changed to cover research and development problems in heavy-water moderated, natural uranium fuelled reactor systems ... the Commission also stresses the desirability of using indigenous uranium resources to fuel Australian reactors'*[79].

There was a strong desire to study reactor systems which were thought to be 'proven'; systems which had been developed, installed and were now functioning as power reactors. According to the Commission 'S*everal different types of reactors may be regarded as proven, viz., graphite moderated, gas cooled systems (using either natural or enriched fuel) as developed in Britain and France; pressurised and boiling light water cooled and moderated systems developed in the USA; and pressurised heavy water cooled and moderated systems developed in Canada and elsewhere*'[80] and '*The United Kingdom is basing its program on advanced gas-cooled reactor plants, Canada and India on heavy water moderated natural uranium system. France continues to build graphite moderated natural uranium stations*'[81]. The apparent dabbling by AAEC scientists and engineers into a number of reactor systems, simultaneously, was part of this ongoing project.

The next step was to look at the different reactor systems and assess which would be the most promising for Australia; '*indications are that ...one of the heavy-water moderated concepts is likely to be the most economic*'[82], '*for countries such as Australia, power reactors which can operate on natural uranium have obvious attractions ... they are to be preferred to systems which require enriched uranium fuel*'[83], '*... great advantages to Australia would flow from a nuclear industry based on indigenous uranium supplies and not on imported fuel*'[84] and finally '*concepts of employing heavy water as moderator and boiling light water coolant are of particular interest:-*

UK	*SGHWR*
Canada	*CANDU- BLW*
Italy	*CIRENE*
US	*HWBLW*[lxv] [85].

[lxv] SGHWR stands for steam generating heavy water reactor
BLW stands for boiling light water
HWBLW stands for heavy water moderated boiling light water cooled

The work that was then beginning to be carried out by Commission staff was based on the assumption that State power generating authorities would not be willing to commit themselves to new and untried technologies for power production. These State authorities were in the electric power production business and were interested only in technologies that would work. Consequently, if the Commission wanted to establish a power reactor network, the AAEC would need to recommend a reactor technology with a proven success record.

Sir Philip Baxter travelled overseas in June 1966 to visit '*a number of countries which are leaders in the development of nuclear power technology. The purpose of the visit was to examine the most recent progress in nuclear power, with special emphasis on nuclear reactors fuelled with natural or near natural uranium and moderated by heavy water. The tour included discussions with nuclear authorities and visits to establishments in Canada, France, Germany, Sweden, the United Kingdom, the United States and the European Atomic Energy Commission*'[86]. The result of this visit was an agreement with the UKAEA to allow the secondment of a number of AAEC staff to work at Winfrith and Risley on a number of aspects associated with this new reactor technology. It was also organised for Commission staff to undertake similar training in Canada. Many of the staff who once worked on the design of an 'Australian' reactor were now part of the new reactor project and were sent to Britain. The Commission had initially sent only '*a small team of engineers and scientists ... to participate in a design study by the United Kingdom Atomic Energy Authority of a natural uranium steam generating heavy water reactor (NSGHW)*'[87]. This group had been sent in late 1966 and early 1967 and included the following scientists/engineers and their families; A.Bicevskis, I.Binns, D.Ebeling, C.Gilbert, D.Higson, B.Lawrence, D.Mercer, A.Parkinson, W.Wright and K.Lawther[88]. The following year the group had greatly expanded to twenty-two in all.

The Commission established a Steam Generating Heavy Water (SGHW) Co-ordinating Committee based at the research establishment at Lucas Heights. This committee was to work on aspects of this reactor system at Lucas Heights while other members of the team were in the UK. This required close and regular communication between the two groups, through the chair of the SGHW Co-ordinating Committee, D.R.Griffiths. The Committee met for the first time on 12th May 1967, shortly after the team that had been sent to the UK had undergone training and started to work on the SGHW project. The Committee initially included representatives from the AAEC, the State Electricity Commission of Victoria and the Ministry of Fuel and Power, Victoria. Later the Committee also included a representative from the Electricity Commission of NSW. The committee did not restrict itself to the work of the team members in the UK, a team had also been sent to Canada to study the CANDU-BLW system and their work too was part of this project[89].

The arrangements for this second team which was sent to Canada had been finalised when '*in March/April 1967 Mr B.F.Dargan ... visited Canada...The purpose of the visit was to enable senior representatives ... to see something of Canada's power industry – both nuclear and conventional ... the visit was particularly successful and provided insight into the impressive Canadian achievement in this field, particularly in the development of heavy water reactors*'[90]. The Commission in its Annual Report of 1968 stated that the '*Commission staff in the UK are assisting the UKAEA staff in design and development of a natural uranium version of the steam generating heavy water reactor now in operation at Winfrith ... Australian staff attached to*

Atomic Energy of Canada Ltd are assisting in the development of ... CANDU BLW – a 250 MW prototype ... expected to commence operating in 1971'[91].

The Steam Generating Heavy Water (SGHW) Co-ordinating Committee was primarily responsible for the engineering aspects of the reactor project. The two AAEC teams sent regular reports to the Committee which acted on the information relayed. The roles of the teams sent to the UK and Canada were different. The British SGHW project was still in the design stage when the Australian contingent arrived and the expectation was that the Australians would take an active design role which initially was accepted by the British. Australia, at this stage was not committed to building a reactor at any specific site; it was however attempting to decide which reactor system would be suitable. Within a few months of the Australian team arriving in Britain, requests for information as to the specific nature of the site on which the reactor was to be built were being made by the UKAEA. Griffiths responded to the British requests in a letter dated 24th August 1967 '*we are now being pressed for additional information which is only needed for the detailed design and costing for a specific site. ...the site to which this data would apply is unlikely to be the one finally selected for this State's first nuclear plant*'[92]. He continued '*from Australia's point of view I should have thought that there would be advantages in producing a semi-standardised design*' and concluded with '*because we are not at present in a position to supply all the detailed site information requested, it has been suggested that the design should proceed on the basis of the New Zealand Oyster Point site*'[93]. There was a very small New Zealand group at the UKAEA working alongside the Australians on the SGWR project and it was their proposed site which is being referred to.

It seems that the British thought that the Australians were going to buy the reactor that they were involved in designing. It appears that there was a misunderstanding between the British and the Australians as to the exact nature of their collaborative work on this project. Britain was going to design a reactor for a specific site while Australia was looking for a reactor design which could be duplicated and built in a number of different sites around the country. The site specifications were important for determining the temperature gradient between the reactor system and the heat exchange system.

The AAEC team sent to Canada, on the other hand, had a completely different role. The CANDU-BLW system design work was virtually all completed by the time the Australian team arrived which meant that '*our people in Canada have essentially a 'watching brief' type of assignment*'[94]. This meant that the Australians were more involved in the developmental work on this reactor. The Canadians were looking at a different type of reactor fuel, one based on a silicon compound with uranium rather than uranium oxide which in itself caused some concern for the AAEC staff who saw this as a new form of technology.

The Co-ordinating Committee was concerned with the power producing potentials of the two systems and used the power engineering expertise of both the representatives of the two Electricity Commissions. It was also concerned with the safety aspects and made various references to the preferred safety criteria required by the systems. There was also some consideration made as to the preferred siting of the power reactor. '*A one-mile exclusion radius is now considered to be unnecessarily restrictive. ... the Commission is suggesting a half-mile exclusion radius under direct control of the responsible authority. This would be surrounded by a semi-rural low* *population zone which could include population pockets of about 500 persons depending on local circumstances. The outer development of urban population centres should be restricted so as not to approach closer than five miles from the centre of the site*[95].

The Commission's research direction now changed; '*...research by the Commission in Australia has three main objectives:-*

- *to provide training and experience in heavy water moderated systems*
- *to establish the supporting technologies in Australia ... especially... to questions of reactor fuel and fuel cycle, as a preliminary step towards the use of Australian produced uranium in future power stations*
- *to obtain a better understanding of the physics, engineering and materials problems of this class of reactor*[96].

This was all part of the Australian power reactor project and incorporated all aspects of the nuclear industry. It was hoped that finally Australia would be able to mine and refine its uranium ore, then process it into fuel elements for a reactor which included the possibility of producing enriched uranium and finally to even reprocess the spent fuel elements.

All was not well in Britain and by 1968, '*...because of other commitments the UKAEA has been unable to devote as much effort to this work (ie SGHWR natural uranium version) as originally intended ... there are still areas subject to appreciable uncertainty*[97]. Keith Alder stated that the SGHW reactor study '*showed that SGHW fuelled with natural uranium would have a positive power (and void) coefficient and therefore would be a "metastable" system. The Canadians found the same thing with the CANDU/BLW at about the same time. So either system needed slight enrichment to be inherently safe*[98]. Doug

Ebeling, who was part of the SGHW study team, had communicated these problems to the Commission and the study was terminated.

There were some very real issues related to the power reactor project that the Commission needed to deal with, specifically the nature of the fuel, was it to be enriched or natural uranium. The British had already demonstrated that the use of natural uranium in their SGHW reactor would result in some major engineering problems associated with the design and construction of such a reactor. There were also problems with enriched uranium; '*there are uncertainties regarding the price and availability of enriched uranium supplies in the post 1975-80 period. It is for such reasons that these heavy water moderated natural uranium reactors are attracting increasing attention particularly from countries having their own uranium supplies*'[99].

Baxter was most impressed with the Canadian, CANDU-BLW system and ensured that the Commission would publish his view on the matter; '*at present, the Canadian PHW concept (CANDU-BLW) is the only concept which could be regarded as proven and suitable for large scale commercial application*'[100] and '*the main advantages of heavy water reactors lie in their fuel cycles ... the Canadian PHW concept will operate on natural uranium, whereas the British SGHWR uses fuel comparable in enrichment with BWRs*'[101]. Senior members of the Commission also went overseas, specifically to Canada and the UK. '*Mr Timbs visited Canada, the USA, the UK, France and Japan. Mr Timbs had discussions with nuclear authorities in each of these countries ... in the development of atomic energy*'[102] and Alder went to Canada and UK in October 1967 '*for discussions relating to Australia's research on heavy water reactor systems*'[103]. The CANDU-BLW was built but since it also proved to have a positive void coefficient it was never operated[104].

The Commonwealth Government had decided, at Baxter's persuasion, that Australia was to get its first power reactor by undertaking a feasibility study. Consequently the Commission was in a position to choose a reactor system which they could then 'sell' to the Government and/or State power generating authorities. The question now was, what type of proven reactor technology would be acceptable to the power authorities? Then there was the question of cost, not only the capital cost in developing and building such a reactor but also the running costs which included the fuel costs. If the running costs were too high then the electricity produced would be too expensive for the consumer to purchase.

The future of the SGHW reactor system for Australia was, by 1969, in doubt '*although the SGHWR system appears to have acceptable prospects when used with enriched uranium fuel, in the natural uranium fuelled versions there are still unsolved problems relating to fuel elements and to reactor stability and safety. It appears doubtful whether the economic prospects of this natural uranium reactor will justify further research and development*'[105]. The AAEC staff concentrated on the CANDU system which was a natural uranium heavy-water-cooled reactor. This was Baxter's favoured design[106].

Baxter and Fairbairn, during February and March 1969, travelled to each of the State capital cities and spoke to the relevant State Ministers on the introduction of a joint Commonwealth-State nuclear power station. Each State Government was invited to send a representative to become a member of the National Consultative Committee on Nuclear Energy[107]. This Consultative Committee was formally established on 13th June 1969 and would '*consider such matters as:-*

the licensing of reactor sites and operations, *the establishment of international obligations on nuclear materials and safeguards,*

the disposal of nuclear waste in respect of public lands and to furnish a solid administrative and legal framework for the country's entry into the generation of nuclear power'[108] .

The Commonwealth saw this committee as the instrument through which the States would become partners with the Commonwealth Government in any future nuclear power developments within Australia. The Committee had its inaugural meeting on 8th June 1970[109]. According to Moyal, the Committee met only once[110].

The first State which was to have nuclear power was not South Australia, as had been the suggestion many years before, but NSW. NSW at this time was governed by the Liberal Party under the leadership of Robin Askin (1909-81) while South Australia was governed by the Australian Labor Party under the leadership of Don Dunstan[lxvi] (b1926). NSW had the major advantage that it had the largest population of any state and therefore had a greater number of potential customers. The NSW electricity grid was also linked to the Victorian electricity grid through the Snowy Mountains Hydro-electric Scheme and NSW also bordered two Commonwealth-owned territories; the ACT and the Jervis Bay area. In June 1969 '*there was an invitation to the NSW government to join the Commonwealth government to collaborate in a feasibility study for the establishment of a 500MW nuclear power station, owned and financed by the Commonwealth, operated by the Electricity Commission of NSW to be established either in the ACT or Jervis Bay'*[111]. The decisions concerning the location of the power reactor were discussed in the previous section. The Commonwealth now established the principles behind any future nuclear power developments, specifically '*Fairbairn publicly declared the*

[lxvi] Dunstan was Premier of South Australia in the period 1967-8 and again 1970-71.

government's commitment to the use of indigenous fuels and the principle of uniform reactor design for all potential nuclear plant developments'[112].

The situation now produced a minor constitutional and legal problem; *'Constitutionally the Commonwealth had no power to generate power (ie electricity) and under the Act the AAEC was limited to the discovery, mining, treatment, use and disposal of uranium'*[113]. This issue was solved by the agreement between the Commonwealth and the State of NSW in which the Commonwealth Government through the AAEC would own the nuclear reactor but any electricity generated from the steam produced would be owned by the State. The process by which this occurred was a simple commercial operation in which the NSW Electricity Commission bought the steam and used it to generate electricity. All was now ready for Australia to establish a power reactor.

Finally, the Commission wanted to keep it options open concerning the latest technology, the fast breeder reactor. It was known that for an economic operation, fast breeder '*reactors require plutonium fuel, but overseas studies indicate that there will be a world shortage of plutonium by the later 1980s. If Australia is to benefit ultimately from these developments, it must take steps now to ensure that supplies of plutonium will be available when required. This will involve the construction of advanced converter stations, preferably burning uranium'*[114]. Later in that report there was mention that Australia may need plutonium for a fast breeder reactor. Specifically it stated that '*it is not generally appreciated how long it would take a country like Australia to accumulate a reasonable stock of plutonium for a fast breeder reactor program. A typical 500 MW heavy water, natural uranium reactor station commissioned in 1975 would only produce sufficient plutonium by the year 2000 to meet the needs of a single 1,000 MW fast breeder station, but by the* *year 2000 many such units might be required annually in Australia. The construction of suitable advanced converter stations should therefore be commenced as soon as economically justifiable'*[115].

This is the first time that the need for plutonium is mentioned in a document from the Commission which was aimed at the public. The following year the Commission, in its Annual Report, stated '*a portion of the non-fissile uranium-238 in the fuel is progressively converted to fissile plutonium. This could be set aside and stored ... a fuel reprocessing plant would then be required to extract the plutonium from the spent fuel elements'*[116]. There was very little work carried out at the Commission on fast breeder reactors at this time nor was there any reference to Australia ever acquiring such a reactor. Furthermore there was no project to explore the development of reprocessing plants for the extraction of plutonium. These comments at first sight seem a little strange, but these statements of intent could have been the method by which the Commission continued to secure funding for its power reactor project, especially if one considers some of the political machinations taking place behind the closed doors of Cabinet which were discussed earlier in this chapter.

6.4 The Need for Uranium and Heavy Water

The decision to build a power reactor raised a number of issues that, up to this time, were dormant. Australia had supplied both Britain and the Combined Development Agency (CDA)[lxvii] with uranium for their reactor projects. It was believed that Australia still had undiscovered uranium deposits which could provide Australia with fuel for a power reactor. The type of fuel was also under consideration, would the reactor require enriched uranium or natural uranium?

[lxvii] This was discussed in Chapter 3.

A number of reactor types were also being considered, some would require heavy water as a moderator. It was considered that if Australia was to maintain some independence in the area of nuclear power reactor development then it would be desirable to use Australian uranium and for Australia to consider producing heavy water.

The desire to have a power reactor fuelled by indigenous uranium invoked a need to ensure that sufficient uranium remained in Australia to meet these new needs. The then-known uranium supplies all had a limited life expectancy and much of the uranium that had been mined was done under contract to an overseas buyer. New uranium deposits were required and the known deposits had to be developed further, wherever possible, to meet Australia's expected demands.

Australia had been producing uranium ore under an agreement with the CDA. Once the contract was fulfilled, uranium production at Rum Jungle continued and the ore was stockpiled. Once the ore body had been exhausted, mining production ceased and the mine was abandoned. The stockpiled uranium ore, however, allowed the '*production of uranium chemical concentrates in Australia continued to be confined to the Commonwealth owned plant at Rum Jungle, where output was stockpiled*'[117]. The Mary Kathleen mine and township had been kept on a 'care and maintenance' basis since 1964.

Exploration for uranium deposits was not a major undertaking at the beginning of this period, however, the price of uranium started to increase due to an increased demand for the ore. It seemed that more nations were developing nuclear power and uranium was now in demand again. The AAEC noted in 1966 that '*a number of US companies have recently been investigating the possibility of commencing uranium prospecting operations in Australia and* *one has entered into an exploration agreement with a local company'*[118]. This renewed interest in uranium ore led to changes both in the need to renew exploration efforts and the export requirements for uranium ore.

The April 1967 announcement on the relaxation of export requirements for uranium ore led to an increased interest in uranium prospecting and exploration. While the Commission confined its uranium exploration program to the Rum Jungle area, other mining companies started to explore over a much larger area[119]. The following year the Commission reported that its *'program of uranium exploration was confined to the Rum Jungle area, Northern Territory'*[120]. It also reported that other companies were busily searching for uranium , these companies included; Australian Mining and Smelting Co Ltd (a subsidiary of Conzinc Riotinto), Mary Kathleen Uranium Ltd, United Uranium N.L., Queensland Mines, Western Nuclear (Australia) Pty Ltd, as well as many other smaller companies[121].

In April 1971, the treatment plant at Rum Jungle was closed since all the stockpiled ore had been used. The plant and equipment at the site were sold at auction since the climatic conditions at Rum Jungle precluded the possibility of putting this on a 'care and maintenance' regime that had been applied to the Mary Kathleen site[122]. Production of uranium ore effectively ceased at this time. Exploration, however, continued apace with '*important new discoveries include some exceptionally high-grade ore'* in the Alligator Rivers area of the Northern Territory[123]. During the following year other discoveries were made in Jabiru, Jacana, Jabiluka and Nabarlek in the Northern Territory. Exploration was also taking place in South Australia where several new ore bodies were discovered, or extensions of existing deposits confirmed. Queensland was being explored, particularly in the Mary Kathleen area, and Western Australia was again being explored for uranium. The

AAEC, in 1973, noted that '*in contrast to the decline in world uranium exploration activity during the year, company exploration increased in Australia*'[124]. The uranium mining boom was about to start.

This exploration also discovered other mineral reserves which included new coal, gas and oil reserves that had previously been unknown, see figure 6-4. Australia by the early 1970s was no longer an energy poor nation but one with energy reserves of all types. The problem that would be faced by the new Labor Government under Whitlam would be how to best develop all these new found resources.

Figure 6-4 Uranium, Coal, Gas and Oil Deposits

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The situation with heavy water was somewhat different. Heavy water occurs naturally in very small quantities and the amount of heavy water in any sample of water varies. The production of heavy water is done in one of two ways; by chemical separation or by electrolysis. Separating heavy water from the normal or light water utilises the fact that deuterium and hydrogen have differing affinities for various compounds at different temperatures. The most common commercially used process employs the hydrogen sulphide/water system (also known as the Girdler-Spevack, GS, process) which is a two stage cascade system[lxviii]. The electrolysis method is the older method and uses huge quantities of energy. Water undergoes an electrolysis reaction in which water is decomposed into hydrogen and oxygen, by the passage of an electric current, leaving behind the heavy water in the unelectrolysed liquid[125].

Australia became interested in the issue of heavy water at much the same time as Australia's interests in reactor fuel fabrication and enrichment became issues of interest. If there was a possibility that Australia could have a power reactor or a string of power reactors with possible heavy water moderation and/or cooling then an independent and reliable source of heavy water was imperative. By the mid 1960s heavy water production was now also coming out from behind the curtain of military secrecy. The first mention of heavy water production by the AAEC was made in 1966 when the Annual Report mentioned that '*the Canadian Government has authorised Atomic Energy of Canada Ltd (AECL) to underwrite the purchase of the full output of a ... heavy water production plant*'[126].

[lxviii] see Appendix 2

The Commission, by 1967, was seriously considering heavy water moderated reactors and hence became increasingly interested in heavy water production technology. The Commission, in its 1969 Annual Report noted

> '*naturally occurring hydrogenous materials (water, petroleum oil, natural gas) all contain heavy hydrogen atoms. ...Most of the world's production has been based on the Girdler-Spevack (GS) process in which chemical exchange of deuterium takes place between water and hydrogen sulphide. The Commission is keeping the supply and demand position under review, and had begun studies for possible future production of heavy water in Australia. Several large industrial concerns in Australia have expressed interest in the prospects for heavy water production locally*'[127].

This coincides with the Commonwealth Government's announcement of the feasibility study for the Jervis Bay reactor project.

The Commission seemed determined that Australia would have an independent source of heavy water: '*the AAEC continually studies world developments in the heavy water field and has begun a survey of the deuterium content of Australian waters. The quantity of deuterium varies in the natural waters of the world ... the Commission has provided information to several large companies in Australia to assist their studies of local production of heavy water*'[128]. The Commission in this particular case did not want to be involved in the commercial development of a heavy water production plant but it did want to secure a locally produced product and would assist in the process.

The interest in heavy water production continued the following year; in 1971 '*the Commission continued to keep abreast of developments in the heavy water field and advises interested companies in Australia on the possibilities* *of local production'*[129]. The Jervis Bay project had by now been cancelled and Australia was not going to get a heavy water moderated power reactor, so an independent source of heavy water was no longer required. A heavy water production plant was never developed in Australia and the Commission also lost interest in its development.

The question remains why did the Commission want this independent source of heavy water? The main heavy water producers in the Western World were allies of Australia. Even if the production of heavy water now rested in the hands of private companies which had the profit motive, Australia would still have been able to secure some heavy water for possible power reactors, even if such a supply was written into the purchase agreement with the reactor manufacturer. This push for an independent supply of not only heavy water but of uranium both in the form of natural uranium and enriched uranium could well have had its impetus from a very different direction.

Australia, in the mid to late 1960s, was finding a new identity within a Southeast Asian context. Australia was no longer looking towards Britain as a partner or an ally nor were the links to the US as strong as they once were. Australia, under Gorton, seemed to be coming out as a more independent nation which could set the agenda in the Southwest Pacific and Southeast Asian context. Australia was no world power but it did have a sphere of influence which could have been nurtured. Was the push to have this independence in nuclear technologies part of a greater export market rather than a military or defence strategy? If nuclear power was the energy source of the future then surely Australia's closest neighbours would be interested in this relatively clean form of almost unlimited power. Who would be better to supply both the materials for this technology and the training of the technicians, engineers and scientists who would build, maintain and operate these new power stations, than Australia?

6.5 The Uranium Fuel Cycle and Enrichment

The enrichment project and a further excursion into controlling the uranium fuel cycle came about as a direct result of the nuclear power project. Australia was a world supplier of uranium oxide ore. After the discoveries of new and more widespread uranium deposits it seemed possible that Australia could not only supply the oxide ore but could process the uranium into a more sophisticated product such as fuel rods or enriched uranium and hence gain an export advantage by selling the more expensive product. If Australia could learn how to reprocess spent reactor fuel rods, then again there would be the possibility of earning more from this specialised industry: *'a proposal and assessment has been prepared for processing at Lucas Heights of HIFAR fuels. The purpose of the project is to provide expertise in the development, design, construction and operation of such plants in Australia and to provide a pilot plant facility for future fuel reprocessing studies'*[130].

The Commission, in 1968, became engaged in research into the uranium fuel cycle, each part of which became a separate research area including the production of uranium hexafluoride, enrichment of uranium, fuel element fabrication and the reprocessing of spent fuel elements. The Minister, David Fairbairn, stated in 1968 that '*a national fuel policy would allow complete control of fissile materials relevant to defence; it would also confer the ability to accumulate and plan the most economic use of an independent source of plutonium for more advanced and economic reactors, including the fast breeder reactors'*[131]. Much of the debate and justification for controlling the uranium fuel cycle seemed to focus on the issue of plutonium and fast breeder reactors. It is unclear at this stage why there was this connection. Fast breeder reactors were at this time the latest innovation and had yet to be proved commercially.

According to Keith Alder, the '*AAEC research and development activities were to facilitate setting up uranium based processing industries in Australia. The largest effort was devoted to the enrichment process to increase the percentage of the fissile uranium isotope U235 from the level of 0.7% in natural uranium to the range 2% -4% for export as nuclear fuel. The AAEC was trying to establish 'process it at home' rather than export as raw material'*[132]. Alder continued that there was '*no uranium processing industry due to political machinations despite Australia having over 30% of the world's economically recoverable uranium ores'*[133]. Further, Alder stated that since '*most reactors use enriched fuel with Australian deposits we had potential to be a major nuclear fuel supplier, enrichment knowhow could protect our supplies of fuel'*[134]. The AAEC was in an ideal situation to demonstrate the practical and economic advantages of Australia controlling the entire uranium fuel cycle.

The work on enrichment started as a 'paper study' by Keith Alder, when in 1963, he returned from an overseas trip to Europe and discovered that a few countries were looking at the centrifuge enrichment process for uranium. At this time the information available on this process was very limited. This initial literature study led to the beginnings of a new research project; centrifuge enrichment[135]. At no time was this work ever considered to be part of a military or defence project. All the literature available indicates that this project had only one end; that of enhancing the monetary value of Australia's uranium exports. A secondary consideration was, undoubtedly, that of ensuring Australia's fuel supply for a power reactor. The Commission started its work on the enrichment of uranium in 1966[136]. The problem of enrichment technology during the 1960s was that the *'development of technology for enriching uranium was 'classified' overseas since this technology could be used to produce weapons-grade enriched uranium. Weapons-grade enriched uranium contains as much as 93% U^{235} whereas reactors seldom require more than 3%'*[137]. Consequently much of the work with the AAEC at this time was also 'classified' with some buildings within the Research Establishment at Lucas Heights having access restricted only to those directly involved in the project concerned and '*because of sensitivity the enrichment project was kept secret, initially called 'Project Whistle''*[138].

The first aspect of controlling the uranium fuel cycle was the production of uranium hexafluoride. According to the AAEC *'since Australia is a potentially large producer and exporter of uranium, it would be in Australia's interest to sell uranium hexafluoride rather than yellowcake ... if enriched uranium dioxide power reactors were to be installed in Australia ... it would be necessary to have facilities for uranium hexafluoride production and conversion to uranium dioxide powder'*[139] and *'a key part of this program is the preparation of nuclear-grade uranium dioxide from 'yellowcake''*[140].

The money earning potential of exporting the more processed material was certainly not lost on the Commission which stated *'rather than export uranium in the form of crude mine concentrate – yellowcake ore – there would be advantages in up-grading the product to uranium hexafluoride'*[141] and that *'it is possible, and may be desirable, to establish a uranium hexafluoride plant in Australia'*[142]. The Commission was certainly exploring the technology for this first stage of the uranium fuel cycle. One aspect that should be noted is that uranium hexafluoride gas is extremely corrosive and consequently difficult to store and transport, hence one would only produce uranium hexafluoride if one was going to take the next step and produce enriched uranium.

The next stage was that of enriching the natural uranium[lxix]. The process of enrichment is one in which the two isotopes of uranium, the fissionable uranium-235 and uranium-238 can be separated from each other in a series of cascading steps. The concentration of uranium-235 would then be successively increased until the desired degree of enrichment had been achieved. This separation process is a physical process which requires the production of uranium hexafluoride gas as the medium in which the two isotopes of uranium are separated.

There were three methods used in the enrichment of uranium; diffusion, the centrifuge and electromagnetic separation. The last is very expensive and was only used in the Manhattan project, at the end of the enrichment process to achieve very high levels of enrichment for weapons. The diffusion method was the original method developed during the Second World War and requires the uranium hexafluoride gas to diffuse through a series of porous membranes. The uranium-235 would pass through slightly more quickly, being lighter than the uranium-238. The centrifuge method requires the uranium hexafluoride gas to pass through a high speed centrifuge in which the two isotopes would be separated. Cascades are required for both the diffusion and centrifuge methods with a higher concentration of uranium-235 occurring after passing through each individual enrichment stage in a series of hundreds of such units.

[lxix] The following is a brief expose of the beginnings of Australia's excursion into the field of uranium enrichment. A more detailed account will be given in the next chapter since the enrichment project was one of the few research projects that would survive not only changes in Prime Minister but also a number of changes of government.

The work on enrichment processes came about from two separate concerns. The first lay in the fact that the sole producer of enriched uranium for sale and export was the US: *'enriched uranium is only available at present from the USAEC plants'*[143]. This dependence on one supplier had caused some concern in other countries, not just Australia: ' *... a number of countries have expressed considerable concern over a continuing dependence on the USA for enriched fuel supplies ... these countries are examining possible alternative means of supply and/or feasibility of employing reactors which will not require continuing supplies of enriched uranium'*[144]. The development of natural uranium reactor systems was, in part, a reaction to this concern.

The second lay in the fact that the US government had decided to 'privatise' the production of enriched uranium: *'in November 1969 the President of the USA announced that the three gaseous diffusion plants in the USA would be transferred to a new Enrichment Directorate'*[145]. This meant that the production of enriched uranium was now no longer seen as a military secret but it also meant that prices of enriched uranium could rise. While the enrichment process was a wholly government concern, pricing of the material was based on some form of government subsidy but once a company had to produce enriched uranium and make a profit, the selling price would reflect this. Hence an international concern over the reliance on US enriched uranium came to the fore; *'there are uncertainties regarding the price and availability of enriched uranium supplies in the post 1975-80 period'*[146]. The AAEC later noted that *'in June the USAEC announced that it would provide access to its uranium enrichment technology to a limited number of US owned companies ... sensitive uranium enrichment technology ... would continue to be classified and require security protection'*[147].

Australia was one amongst a number of countries which decided to attempt to establish their own enrichment plants. The first objective was to determine the type of enrichment process which could best suit Australia's needs. The proven technology was the diffusion process which had been developed during the Manhattan Project. A new type of process, the gas centrifuge enrichment process was being developed overseas and was seen as a possible process for Australia.

The AAEC explored the different methods of enrichment: *'a further major step in the establishment of an Australian nuclear fuel industry could be the construction of a uranium enrichment plant ... the possibility is being explored of setting up an enrichment plant using the gaseous diffusion process in Australia as a multinational venture ... an alternative is the centrifuge process ... the Commission has been carrying out research on this process since 1966'*[148]. The older technology was, as has already been mentioned, gaseous diffusion: *'although a number of methods have been studied for the enrichment of uranium, only one has been used to date for quantity production. This is the process known as gaseous diffusion, in which a volatile compound of uranium- the hexafluoride-is diffused through porous membranes (barriers) ... in the Western World only three countries possess diffusion plants, viz, the USA, UK and France and these plants were constructed initially for military purposes'*[149]. See the schematic diagram of a diffusion enrichment plant in figure 6-5.

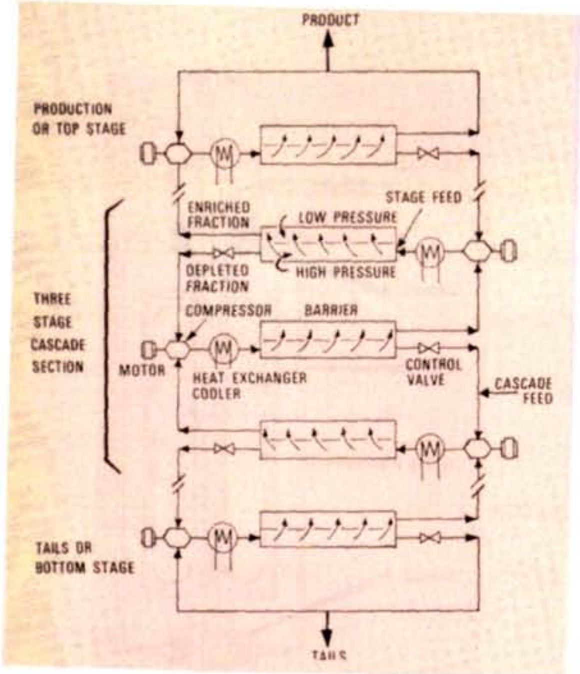

Figure 6-5 Schematic Diagram of a Diffusion Enrichment Unit

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Baxter supported uranium enrichment and the gas-centrifuge technology seemed to be the most promising new method[150]. This new gas centrifuge or ultra centrifuge method was being developed in the UK, USA, Germany, Holland and Japan[151] and *'Australia, through the AAEC, is also progressing with its work on the centrifuge'*[152]. The Commission, in a submission to Cabinet noted

> *'several years ago Cabinet approved a program by the Commission on the gas centrifuge process for separating the isotopes of uranium. This work has made good progress…workable machines have been devised and built and … a small cascade of machines will shortly be completed and design studies relating to a pilot plant are being made …a number of stages of research must be completed before firm proposals for the pilot plant can be submitted. The Commission is proceeding with this work. It is hoped to make a submission for a pilot plant to Cabinet in 1972'*[153].

See the schematic diagram of a centrifuge enrichment unit in figure 6-6.

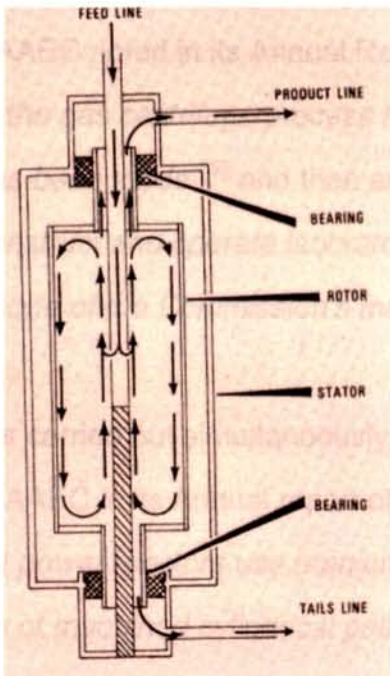

Figure 6-6 Schematic of a Centrifuge Unit

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By 1969 the work on the centrifuge enrichment process had reached the stage at which the pilot centrifuges could spin at a sufficiently high speed for an acceptable level in the separation of the two isotopes. Doug Ebeling, who had been in Britain as part of the SGHWR study group, returned to Lucas Heights to take charge of the Centrifuge Enrichment Project. He was to develop the centrifuges to the stage of running a pilot cascade plant which could demonstrate that this technology was commercially viable. According to Ebeling the secrecy surrounding the project was related to two separate issues. One was commercial-in-confidence in which Australia was developing a new technology and wished to guard any possible commercial advantage through patents. The other issue was the Nuclear Non-Proliferation Treaty which Australia was considering signing. Under the terms of the Treaty Australia could not gain access to or even exchange information from other nations involved with centrifuge enrichment unless Australia could demonstrate that Australia had already developed this technology[154].

In successive years the AAEC noted in its Annual Reports of 1970-72, that '*the AAEC's program on the gas centrifuge process has continued and encouraging progress has been made*'[155] and then announced that *'the Commission began to construct and operate laboratory-scale cascades. The centrifuge project is now one of the Commission's major research projects*'[156].

The enrichment work was carried out simultaneously with work on fuel element fabrication. The AAEC in its Annual report of 1968 noted that

> '*almost all current power reactors use uranium dioxide (UO_2) fuel, usually in the form of machined cylindrical pellets which are pressed and sintered from sinterable nuclear-grade powder to yield a microstructure which has closely controlled porosity and grain size ... the conventional route for production of ceramic grade uranium dioxide involves the dissolution of yellowcake in nitric acid, purification by solvent extraction, precipitation with ammonia, filtration and drying of the ammonium diuranate, followed by calcination and reduction in hydrogen using simple batch equipment*'[157].

The Commission explored the production of nuclear grade uranium dioxide powder, fabrication of uranium dioxide pellets, fuel process materials, zirconium alloy fuel tubing and fuel assemblies and zirconium alloy pressure tubes[158]. During the late 1960s the Commission even produced some small scale fuel elements on which further studies were conducted.

Reprocessing of spent fuel elements was also being explored, particularly utilising some of the spent fuel elements from HIFAR. The Commission noted that *'chemical reprocessing of reactor fuels leads to the separation of highly radioactive wastes consisting mainly of fission product elements. Processes* *for their safe handling, concentration and disposal are required"*[159]. The requirements of such a reprocessing plant were and still are very expensive. Extracting the various fission products requires a number of different chemical plants. The material being handled is highly radioactive and hence requires careful biological and environmental screening. In short the process is messy, dangerous and expensive. While the Commission toyed with the idea and explored some of the technology, a reprocessing plant was never really considered as a commercial venture.

The development of lasers and laser technology led to the development of yet another possibility for isotope separation. Needless to say, Australia became involved in the development of laser-based isotope separation techniques. This will be discussed in the next chapter.

6.6 Tenders Are Called

The Commission had by the late 1960s accepted the fact that an Australian designed and built power reactor would never eventuate, but there was some possibility that a power reactor purchased from overseas could be constructed in Australia. A proven technology with all the costs and risk assessments available for perusal would be acceptable both to the Australian electorate and to the politicians and bureaucrats who ran the country. Australia was now in the market to buy a nuclear power reactor. This seemingly simple process was itself plagued by debate, not public debate but private debates and machinations in government and the AAEC.

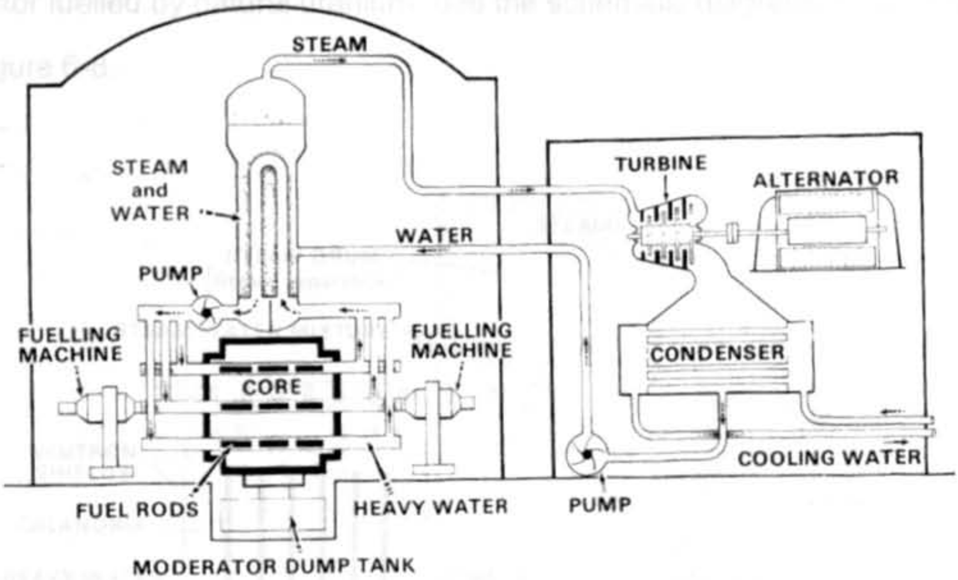

Figure 6-7 CANDU Reactor Schematic Diagram

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Baxter very strongly favoured the original CANDU and the CANDU-BLW type of reactor that was being developed by the Canadians, see schematic diagram of a CANDU reactor in figure 6-7. This was demonstrated by the repeated references through the AAEC Annual Reports which from 1967 '*show a strong interest in the Canadian CANDU-BLW type; natural uranium fuelled, heavy water moderated and cooled reactor*'[lxx,160]. The other contender was the '*the British ... steam generating heavy water moderated, light water cooled reactor (SGHWR), but this used enriched uranium and its cost was 30% below the CANDU-BLW reactor for the same output*'[161]. The British were still certain that they could sell their prototype reactor to Australia just as they had sold Australia the DIDO reactor instead of assisting Australia to develop a power reactor. This attitude remained despite the fact that the SGHWR type of reactor required slightly enriched uranium fuel and Australia wanted a

[lxx] Moyal has in this quote mixed up the CANDU and the CANDU-BLW reactors. The latter used boiling light water, not heavy water for moderation.

reactor fuelled by natural uranium. See the schematic diagram of the SGHWR in figure 6-8.

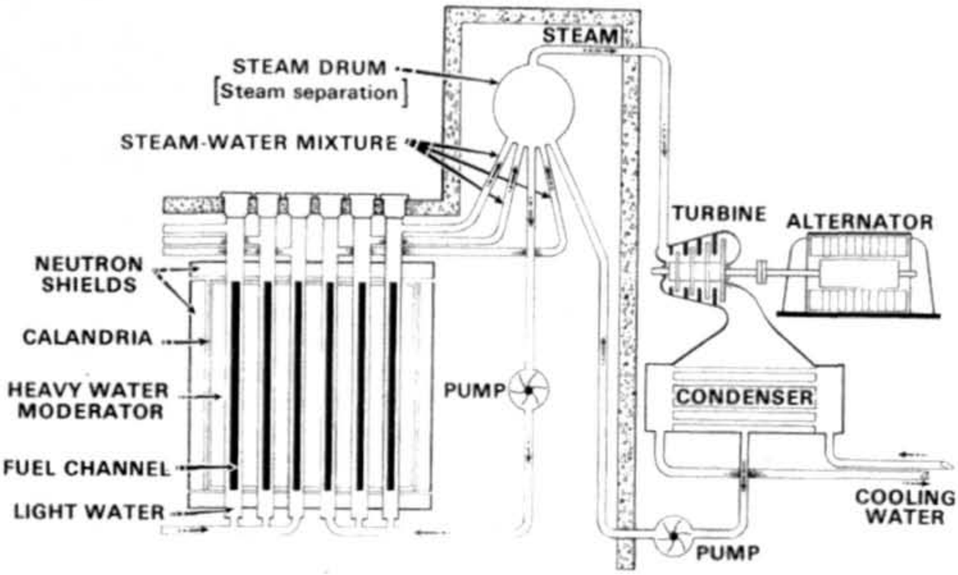

Figure 6-8 SGHWR Schematic Diagram

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According to Moyal, other contenders were '*the American light water reactors using slightly enriched uranium, these were of two types; the boiling water reactor (BWR) and the pressurised water reactor (PWR)*'[162] and the '*the plutonium fast breeder reactor which had been pioneered by the US Atomic Energy Commission and the French Atomic Energy Agency*'[163]. See figure 6-9 for a schematic diagram of the BWR reactor and figure 6-10 for a schematic diagram of the PWR reactor.

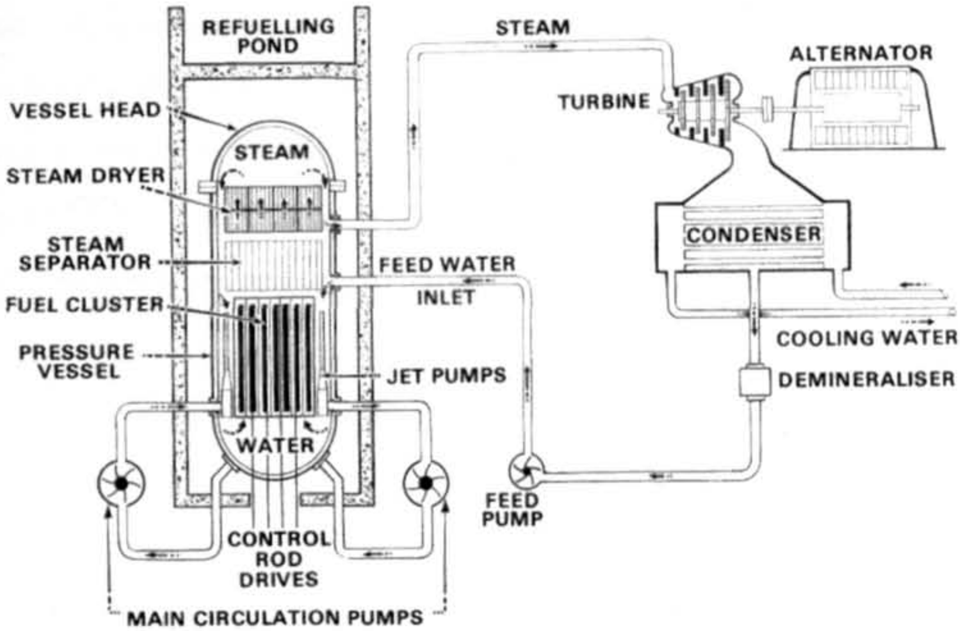

Figure 6-9 BWR Schematic Diagram

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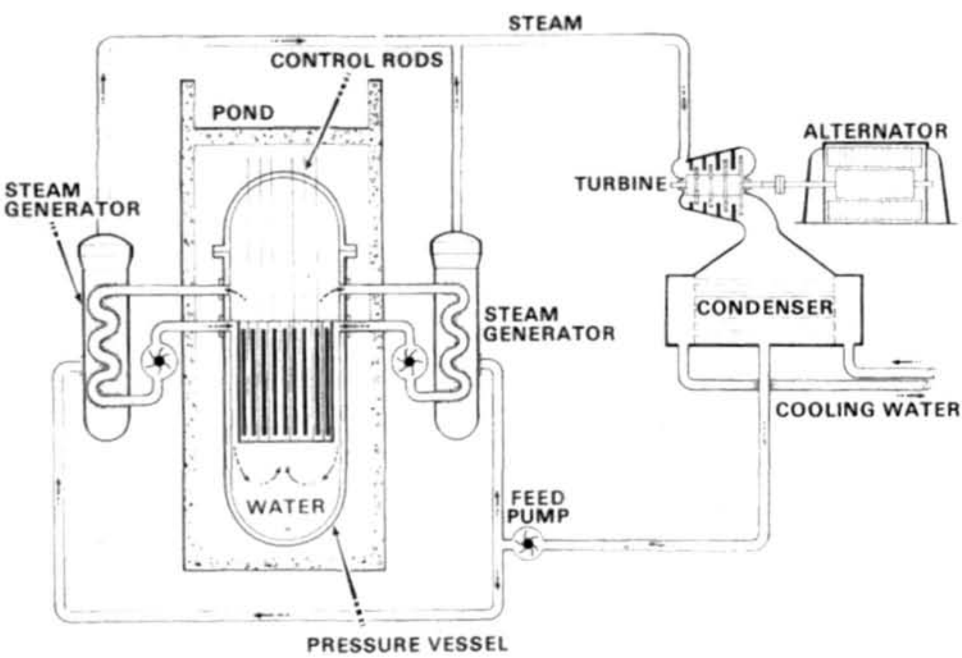

Figure 6-10 PWR Schematic Diagram

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There was virtually no public debate on the issues surrounding the establishment of Australia's first nuclear power reactor. The nearest that the debate came to airing an opposing view was in the confines of Parliament when Rex Connor, Labor's spokesman on nuclear energy, speaking in the

House of Representatives on 11th September 1969 '*emphasised that the Labor Party was not opposed to a nuclear reactor but that it wanted to 'look very hard at the type, price and the function of the reactor proposed by the Government''*[164]. He suggested that the AAEC should re-examine the CANDU-BLW type of reactor and consider instead a fast breeder reactor[165].

Australia had little expertise in setting up the requirements for a nuclear power reactor, never having built or purchased one before. In November 1969 and according to Moyal, at Maurice Timbs' insistence[166], the AAEC engaged a firm of nuclear engineering consultants from the US, Bechtel Pacific Corporation Ltd[167]. These engineering consultants were to '*assist in drawing up specifications and assessing the proposals'*[168]. On 5th December 1969 the AAEC '*sent a letter to 14 leading nuclear energy engineering supply organisations, inviting them to express their interest in tendering'*[169]. The Commission supplied these organisations with details on the Jervis Bay site and the local conditions at this site, it included the Commission's requirements for the reactor and included a time line for the proposal. Ten of these fourteen companies requested detailed specifications so they could consider tendering for the project.

The technical specifications for the reactor were written in Australia before the team of four engineers left Australia in late December 1969 to start work with the consultants on the contract specifications for the project; the '*four engineers; three from AAEC and one from NSW Electricity Commission went to San Francisco'*[170]. The draft contract conditions for the tender process were sent back to Australia for comments and revision by the AAEC, the Commonwealth Government and the Electricity Commission of NSW. The revised specifications were issued from San Francisco on 28th February 1969.

Tenders were invited for four types of reactor system:-

a boiling light water reactor,

a pressurised light water reactor,

a boiling heavy water reactor and

a pressurised water reactor using a heavy water moderator and employing pressure tubes or a pressure vessel[171].

See figure 6-11 for a schematic diagram of a Pressurised Heavy Water Reactor (PHWR). The tender document assumed that the fuel would be uranium dioxide and that the output would be 500MW. It further stated that '*the Jervis Bay Nuclear Power Station should become fully independent of overseas supplies and services*'[172]. The specifications included an unusual requirement for that time, namely that all the drawings, data information and calculations were to be in metric units. At this time Australia, and most of the English speaking world, still used the British units but it was foreseen that Australia would eventually go metric and, since this was to be the first of many power reactors, its plans were designed for the future.

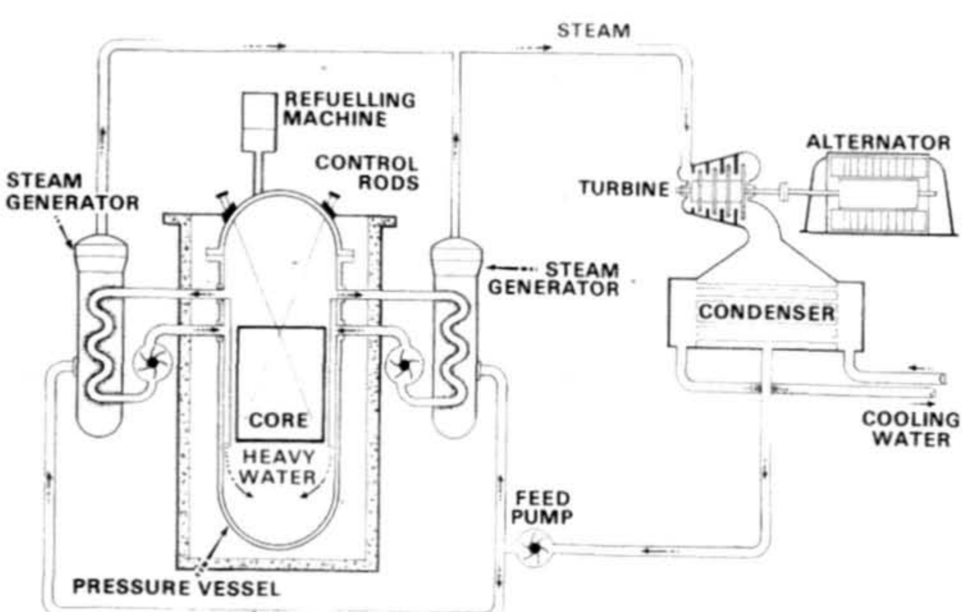

Figure 6-11 PHWR Schematic Diagram

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The Tender Document required that all prospective companies were to lodge a 'notice of intent to tender' by 15th April 1970. Three companies withdrew from the process at this stage and when the tenders closed on 15th June there were fourteen tenders from seven organisations from four countries. These included:-

'***Canada.*** *Atomic Energy of Canada offered a pressurised heavy water reactor... This system uses heavy water as the moderator and natural uranium fuel. Two bids were submitted for essentially the one kind of station, but with alternative contract conditions.*

Germany. *Kraftwerk Union tendered three systems – a boiling water reactor ... and a pressurised water reactor ... both of which employ ordinary water and enriched uranium fuel – and also a PHWR. Two bids were submitted for the latter, in different sizes.*

Great Britain. *British Nuclear Design and Construction Ltd and the Nuclear Power Group Ltd each tendered for a steam generating heavy water reactor ... the latter submitted four tenders – for two different sizes, and under two kinds of contracts. It offered a nuclear steam supply system in each size, and also offered `turnkey' contracts ...*

USA. *Combustion Engineering Inc offered a PWR, General Electric Company a BWR and Westinghouse Electric International a PWR'* [173] .

It should be noted that all the discussions involving the tender process were in line with the construction of a power reactor and hence power output and efficiency were significant. Details of these tenders were tabulated and presented to Cabinet with the recommendation that the short list of tenderers be reduced to four who would then be asked to supply more detailed and specific information on both the construction and contractual arrangements for further consideration. Cabinet accepted the Commission's recommendation on August 18th 1970. The four short listed tenderers were:-

Atomic Energy of Canada's heavy water reactor,

Nuclear Power Group's steam generating heavy water reactor,

Kraftwerk Union's pressurised water reactor and

Westinghouse Electric's pressurised water reactor[174].

Representatives from these four companies met with the AAEC staff and Bechtel and most of the information sought by the AAEC was received by the required deadline of 30th September 1970[175]. The three firms whose reactors required enriched uranium offered an enrichment service as part of their revised contract. The Canadians whose reactor used natural uranium did not need to offer this service[176]. The sparring within the Commission, especially between Baxter and Timbs, as to which type of reactor should be chosen, was now becoming more obvious.

Maurice Timbs, the executive member of the AAEC and the AAEC administrator, considered CANDU-BLW as not being particularly safe. He had insisted on changing the original draft of the tender from "*the reactor must be capable of operating on indigenous fuel, ie fuel which could be prepared and manufactured entirely from within Australia from Australian resources' by inserting the rider that the successful tender would ensure, within 5 years of completion of the station, that facilities were available for the manufacture of enriched uranium in Australia*'[177]. Baxter on the other hand supported the Canadian natural uranium reactor, but even here he was about to change his mind.

The two reports available about what occurred next are contradictory. According to Ann Moyal, Baxter called together some of the group from the

AAEC who were evaluating the tenders. Baxter timed his meeting in early October 1970 when Maurice Timbs was overseas and before the arrival of the Bechtel report. The purpose of this meeting was to '*make a formal recommendation on the reactor to be selected, with additional guidelines that the reactor should be 'a good plutonium producer"* [178] . This group recommended the Nuclear Power Group's steam generating heavy water reactor, with the CANDU reactor as the second choice. This recommendation, however, was not supported by the Electricity Commission of NSW or by the Bechtel Corporation. Both these groups were supporting the acceptance of either the Kraftwerk Union or the Westinghouse tenders. Maurice Timbs also supported the Westinghouse pressurised water reactor technology[179].

Alder's version of the same events are as follows, '*the final meetings with the tenderers were plenary sessions which I chaired at Coogee. Timbs was back by then and we had the Bechtel report ... Timbs did not attend the meetings'*[180]. One of the tenderers was not initially responding to all the questions asked by the group evaluating the tenders. Eventually, all the questions pertaining to the tenders were satisfactorily resolved. Bechtel had come out in favour of the Westinghouse tender which was hardly surprising since they were '*heavily involved with both Westinghouse and the USAEC as consultants'*[181] and that Westinghouse was the only tender from the US.

It appears that the Westinghouse tender was supported by both Timbs and Bechtel, Baxter supported the CANDU tender, the AAEC group supported the Nuclear Power Group tender and there is now some doubt as to which tender the Electricity Commission of NSW actually did support. Needless to say there appeared to be some conflict as to which tender to select. This conflict would later explode with Timbs actively undermining Baxter and perhaps either directly or indirectly resulting in the cancellation of the entire project.

Baxter, in November 1970, decided to secretly[lxxi] contact two of the tenderers, Atomic Energy of Canada and the Nuclear Power Group. He invited both companies to submit a further bid based on a turnkey arrangement. Atomic Energy of Canada and the Nuclear Power Group put in their revised bids. The other tenderers were ignorant of these proceedings. The Nuclear Power Group sent representatives to Australia to present their new bid and in January 1971 were involved in a series of meetings chaired by Keith Alder. The Commission now supported the new tender from the Nuclear Power Group as the preferred tender with the associated increased costs of the turnkey arrangement[182]. See diagram 6-12 for an artist's impression of the Jervis Bay reactor.

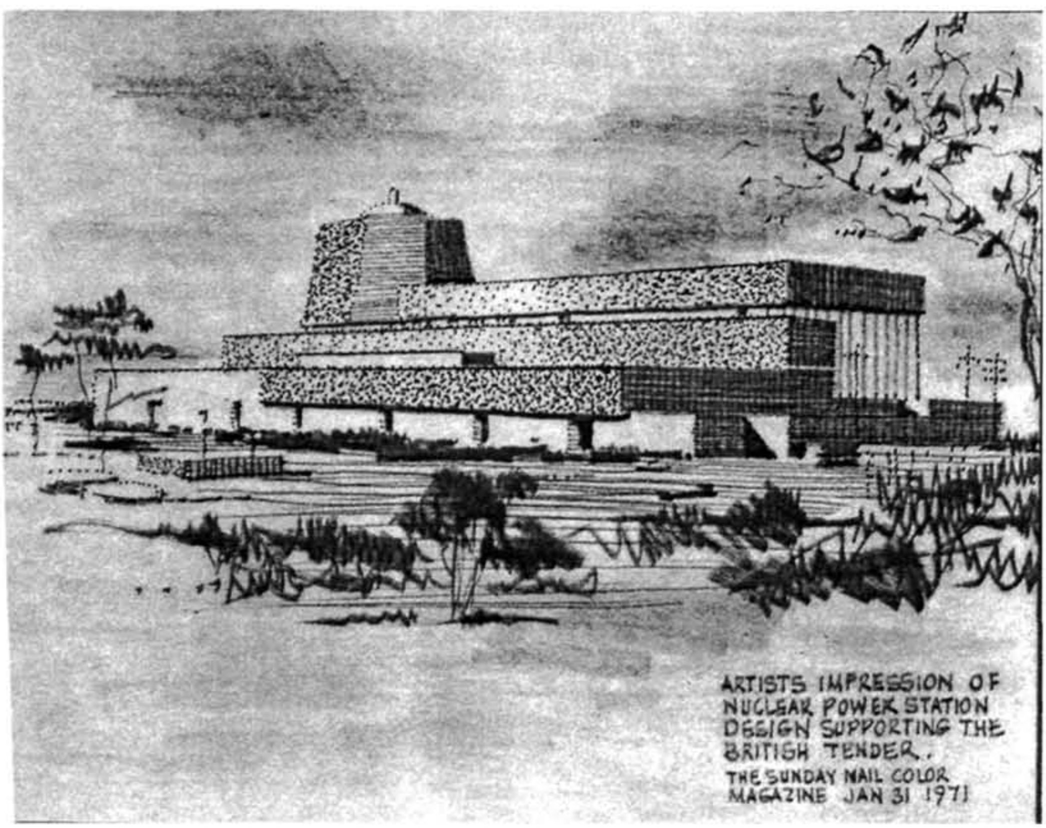

Figure 6-12 Artist's Impression of the Jervis Bay Reactor

Courtesy of ANSTO

[lxxi] According to Keith Alder this secrecy was of a commercial nature.

According to Baxter, '*the final choice of the British SGHWR was made on three main grounds: that though the capital cost was not the lowest it was acceptable when operation matters were taken into account; it did not depend upon a continuing supply of enriched uranium from overseas; it was, in our opinion, after the most careful examination, superior to the other systems in regard to safety ... This was Australia's first nuclear power station, and it was important that we should be able to assure the public that it was the safest possible. The technical members of the Commission subscribed to this view. The non-technical member* (Timbs) *accepted the assurances of American reactor salesmen that their system was the best, but we did not consider his judgement to be technically informed*'[183].

The new reactor would require slightly enriched fuel, something that could easily be accommodated by the Commission which, by this time, was developing a research program in enrichment techniques. The enrichment of uranium could also serve as a good export commodity attracting a much higher export price than that of uranium in the form of yellowcake. It appeared that Baxter was willing to lose his plutonium producing reactor in favour of an enrichment research program (this will be discussed in more detail in the next chapter).

In recent years it has been suggested by some historians, such as Wayne Reynolds, that the dispute between Timbs and Baxter on which reactor to purchase was not related to its potential as a power reactor but as a plutonium producing reactor[lxxii]. The Canadian CANDU reactor was indeed capable of producing plutonium and it did offer the additional benefit that it could accommodate on-line fuel changing. It is also believed that the Nuclear

[lxxii] See 'Australia's Bid for the Bomb' by Wayne Reynolds, Melbourne University Press 2000

Power Group's reactor had an on-line fuel changing facility. On-line fuel changing is a feature of all reactors producing weapons-grade plutonium[184]. It is still difficult to ascertain conclusively whether the Jervis Bay project was a power project or a defence project. The scientists and engineers who worked on it believed it to be a power reactor and all the engineering decisions made by them were based on a power reactor scenario.

6.7 A Change in Prime Minister, a Moratorium and the Project Dies

All did not fare well for the Commission and the new power reactor. The AAEC had recommended the Nuclear Power Group's tender for a steam generating heavy water power reactor to be purchased on a turnkey basis. Work at the Jervis Bay site continued with the anticipation that reactor construction would commence as soon as the contracts were signed.

The public were largely ignorant of these events despite the Labor Opposition's attempts to raise the issue in the House of Representatives by questioning the Government on a number of issues relating to the reactor project. Specifically, why was the reactor being built, why was it located at Jervis Bay and other questions relating to the environmental impact, reactor safety, precautions against internal explosions of the reactor core and the dangers of destruction by enemy submarines[185]. The Government responded to these questions by giving the following reasons for the project to be undertaken: gaining experience in contracting for, constructing, commissioning and operating nuclear power stations, to assist in establishing nuclear industrial potential of exacting standards and to enable Australia to take advantage of prospective major cost savings from fast breeder reactors when they become available[186].

The issue of the relative merits of the two systems which were listed by the Commission, the SGHWR and CANDU-BLW, were treated evasively by the Minister. This led the Labor Opposition to voice its objections to both the policy and procedures over Jervis Bay in the Appropriation Bill of Oct 1970. Specifically, the Labor Party objected to the government not ratifying the Non-Proliferation Treaty which Australia had signed in February 1970. This action, the Opposition believed, restricted Australia's technological choices to obsolete or obsolescent reactors such as the CANDU-BLW and SGHWR. The whole project was effectively conducted in secrecy and there was no way by which Parliament or the Australian people could assess the real merits of the government proposals [187].

The Labor party was not the only group with severe misgivings concerning the project. In March 1971 John Gorton lost his position as Prime Minister. The new Prime Minister, William McMahon had been opposed to the project from the beginning. As Treasurer, he tended not to support the AAEC in its various ventures and when the question of the power reactor came into the Cabinet Room, McMahon opposed it, even making a separate submission against the reactor to Cabinet.

The issue for McMahon was the cost. He had objected to the project initially because he believed that the capital cost of the reactor was too high to make commercially economic electrical power. The new tender price was more than double its original estimated costs and this alone was enough for McMahon. On 9th June, the Minister for National Development Mr Swartz announced that the Government had decided to defer the final decision on the Jervis Bay Nuclear Power Station tenders for a period of twelve months. The Commission immediately suspended all work on the Jervis Bay site[188].

McMahon then immediately ordered an investigation in to the potential costs of developing a nuclear power station. This investigation was done without input from the AAEC and was based on the tender prices only. Swartz announced to Parliament on 18th August 1971, almost 8 weeks after McMahon's initial decision to defer the tender process, that the costs for the development of the power reactor were much higher than initially expected and consequently McMahon placed a moratorium on the Jervis Bay project for twelve months. After this period it was anticipated that the project would be reviewed on the basis of Australia's economic situation at that time[189].

The reality was that no one really then expected the project to proceed. The tender documents had not been signed and there was very little likelihood that the successful tenderer would expect a sudden change of heart on the part of the Government. McMahon, on the other hand did not want to kill the project until he had assessed the international situation with respect to nuclear power, Australia's defence capabilities and the war in Vietnam and Australia's commitments there.

The staff at the AAEC were both shocked and stunned by the decision. Some of the scientists and engineers who had been involved with the project were on the verge of selling their homes in Sydney, purchasing land on which to build new houses in the Jervis Bay area and for some the move also meant accommodating their children in Sydney boarding schools. Families had experienced major disruptions which then had to be reversed. Baxter was outraged. He had been a member of the Commission since its inception and the research direction of the Commission had always been to the ultimate construction of a nuclear power plant. It now appeared that a nuclear power station would not be built in Australia.

The twelve month moratorium resulted in what everyone expected; the suspension of the project. In June 1972 the Minister for National Development announced the indefinite deferral of the power station[190]. It is of interest to note that the AAEC in its Annual report of 1972 stated '*the Commonwealth Government again deferred a decision on the Jervis Bay Nuclear Power Station'* [191]. Baxter was unwilling to give up but the project no longer existed and no tenders had been accepted.

McMahon had never been fully convinced of the viability of the project. He had thought that any technology used in the production of electrical power had to be economically competitive with the cost of electricity produced in conventional power stations. He believed that nuclear power would require an unacceptably high level of government subsidy to make it competitive[192]. He seemed to have very few doubts about his role in the suspension of the project. The Commission on the other hand viewed the power reactor as a project which would be used '*for training, experience, developing a regulatory framework (important in Commonwealth/State relations) ... It went far beyond competitiveness with coal'*[193]. The conflict between the Commission and McMahon and Treasury seemed to be based on two distinct notions of the purpose behind the reactor project.

The attitude of the Minister and of Cabinet was somewhat divided. The Government had cancelled the nuclear power project but it supported and financed the Critical Facility which was still being built at Lucas Heights and as noted in the AAEC Annual Report *'The Minister said that the Commission would continue to study nuclear power station development and experience overseas'*[194]. The Report further stated that *'the primary aim of the Commission in relation to nuclear power reactors is to develop and maintain sufficient expertise to be able to give detailed technical advice readily on the* *performance, evaluation and safety assessment of future power reactors'*[195]. The Critical Facility became the 'sweetener' which was used to pacify the Commission employees.

Baxter retired as the Chairman of the Commission shortly after. He was perhaps exhausted from the endless years of working towards making Australia a leader in nuclear power technology and effectively failing to achieve this not once but several times. The Jervis Bay project was his last battle. The Executive Member of the Commission, Maurice Timbs would resign the following year, after the election resulted in a new Labor Government under Gough Whitlam.

Initially, nuclear research was to provide Australia with a 'cadre of experts' and these experts could then assess the viability of nuclear power production and the types of nuclear power plant which could best suit Australia. The period starting in the early 1970s saw a rise of environmental movements around the world. Nuclear power with its associations of weapons production and perceived risks due to problems with the containment and disposal of fission products was now seen as an environmental hazard. A worldwide search for more acceptable forms of energy production became the focus of both scientists and environmental groups.

6.8 The Critical Facility

The Critical Facility was the brainchild of Mr Bill Gemmell '*who had worked with similar facilities at the Argonne National Laboratory in the USA'*[196]. This facility was designed to enable the AAEC scientists to experiment with a variety of nuclear reactor core designs. The Critical Facility was designed to allow experimentation not only with different core assemblies but with different types of fuel. This facility would be a low power machine which would not require extra cooling but would allow for accurate measurements of neutrons, their distribution and their energies.

The Commission described the Facility as *'a large, low power critical facility for reactor physics studies. With its designed flexibility in construction and use, the facility will allow investigation of a wide variety of reactor problems including those associated with the use of plutonium in advanced thermal reactors and in fast reactors'*[197]. It would be *'a general purpose machine for reactor physics studies, the split-table Critical Facility ... provides the means of constructing and simulating a wide variety of reactors (including fast reactors) with ease and flexibility and safety which make it ideal for research in support of developments in the nuclear industry'*[198].

The Critical Facility would require some form of fuel and in March 1968, the AAEC was searching for a supply of '*some 3 tonnes of natural uranium metal ... we would like it in the form of circular rods of around one inch in diameter and of any reasonable length'*[199]. The AAEC was after the uranium metal in the cheapest possible form and were willing to accept any of the following; '*to buy billets and cast them into rods at Lucas Heights ... to buy Magnox reactor rods, ready clad ... obtain 'reject' Magnox bars'*[200]. The search was started in Britain.

The project required the construction of a split-table machine[lxxiii] for these studies which '*must be capable of high precision reproducibility together with maximum flexibility of operation'*[201]. The advertisements for expressions of interest to tender for the construction for this facility were placed in

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[lxxiii] This was a machine made of two parts which had been very carefully constructed so that when joined, the two parts met perfectly.

newspapers on the 29th June 1967 in the UK, France and Germany. There were a number of companies interested in the project and which applied to tender for it. In March 1968, it was decided to proceed with the next stage of the project and this is where the politics made the process even more interesting.

Maurice Timbs sent a letter on 20th December 1968 to Bob Fry, the Atomic Energy Adviser at the Australian High Commission in London, describing the situation that had arisen between Australia and the UK. Two firms were asked to tender for the facility, a French firm and a British firm. Timbs and the AAEC '*were anxious to ensure that wherever the order was placed we would not find ourselves having ordered a piece of equipment and then having export of that equipment prohibited if Australia did not sign the Non-proliferation Treaty*'[202].

A problem had arisen when Timbs approached both France and Britain to find out their positions on the issue of safeguards. The British would only provide the materials, specifically the fuel for the facility, after Australia had independently negotiated an agreement with the IAEA: '*we had no intention whatsoever of negotiating with the IAEA on this matter*'[203]. The British in their negotiation over the tender agreement failed to give the AAEC their responses within the required time and the tender was given to the French firm in December 1968. The British then questioned why Australia had made their decision against them and this lead to a level of anger towards the British, especially on the part of Maurice Timbs, that was unprecedented.

The tone of a letter, dated 20th December 1968 indicated the anger that Timbs felt for the British on this issue;

> '*if we are going to obtain fuel from the United States, as is likely, we will be very happy to do this within the context of our Agreement with the*

United States and therefore it will come under IAEA Safeguards. This will not require a separate negotiation as we understand it. ... if we obtain our fuel from elsewhere or if we produce it ourselves, we are not going to be bound by the United Kingdom, or for that matter any other country, to bring our fuel supplies under IAEA Safeguards unless the supplying country supplies on this basis and we accept it on this basis ... it is unlikely that we will purchase fuel from the French, we will obtain it from the USA under IAEA Safeguards, but we are not prepared to be told by the UK that all of the fuel used in any facility in Australia must be subject to IAEA Safeguards'[204].

The matter was not allowed to rest with simple representations to the Australian High Commission. Britain now made a more formal complaint to the Australian Department of External Affairs, and again Timbs wrote a response, on 3rd February 1969. His annoyance and anger are obvious;

'*we were anxious, of course, to ensure that if this equipment was to be ordered and constructed there would be no intervention to declare it a prohibited export unless Australia signed the Non-Proliferation Treaty. The British replied that the authority would be given to export the equipment if the equipment was subject to IAEA Safeguards. ... The Commission informed them that this was unacceptable. ...The British thereupon reviewed their position and stated that authority would be given for the equipment to be exported without safeguards provided the fuel used therein was made subject to IAEA Safeguards. They were told that this was unacceptable ... the British cannot supply the highly enriched fuel that is required for the equipment and they were therefore endeavouring to impose political conditions on the use of fuel purchased from a third country. ... Great Britain offers no advantages whatsoever over French technology in the nuclear field'*[205].

It will be recalled that, in 1968, the AAEC abandoned the SGHWR training of its staff since it had been shown that the British SGHWR reactor fuelled with natural uranium had major design problems. Perhaps the AAEC was a little tired of their involvement with Britain and the virtual lack of success for Australia in any of these joint ventures. The British on the other hand probably felt annoyed with Australia for choosing a French company over a British one. There was always some animosity between the British and the French but now in the late 1960s France appeared to be on its way to becoming a world nuclear power, both in a civil and military sense.

Needless to say the AAEC proudly announced that *'construction is being undertaken at Lucas Heights by the French organisation Groupment Atomique Alsacienne Atlantique in association with Saint Gobain Techniques Nouvelles and M.R.Hornibrook (NSW) Pty Ltd*[206]. Two years later the AAEC stated that *'... the Commission began building a critical facility for reactor physics studies. The facility will cost more than one million dollars and will make possible experimental studies of the physics of plutonium utilisation, reactor operating problems and advanced reactor concepts. Nuclear safety is achieved by constructing a reactor core assembly in two separate parts within a large concrete cell, and moving these parts together in an accurate and reproducible manner by remote control*[207].

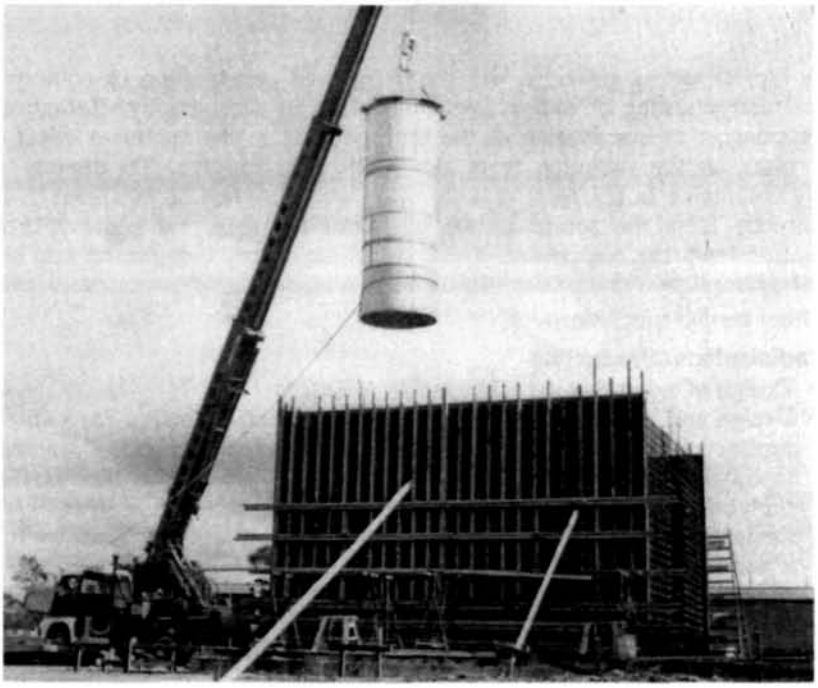

Figure 6-13 Critical Facility Under Construction
P92 AAEC Annual Report 1970

The facility was completed and commissioned in 1972. The facility was officially opened by the Prime Minister, William McMahon, in June 1972[208]. Virtually as soon as the Critical Facility was operational, work on fast breeder reactor systems started. The presence of this new facility meant that the older low power MOATA reactor was no longer required as a research tool for reactor fuel designs. The Commission '*concluded that MOATA's main function would lie in the area of neutron beam facilities for research and in the provision of … facilities for neutron activation analysis'*[209].

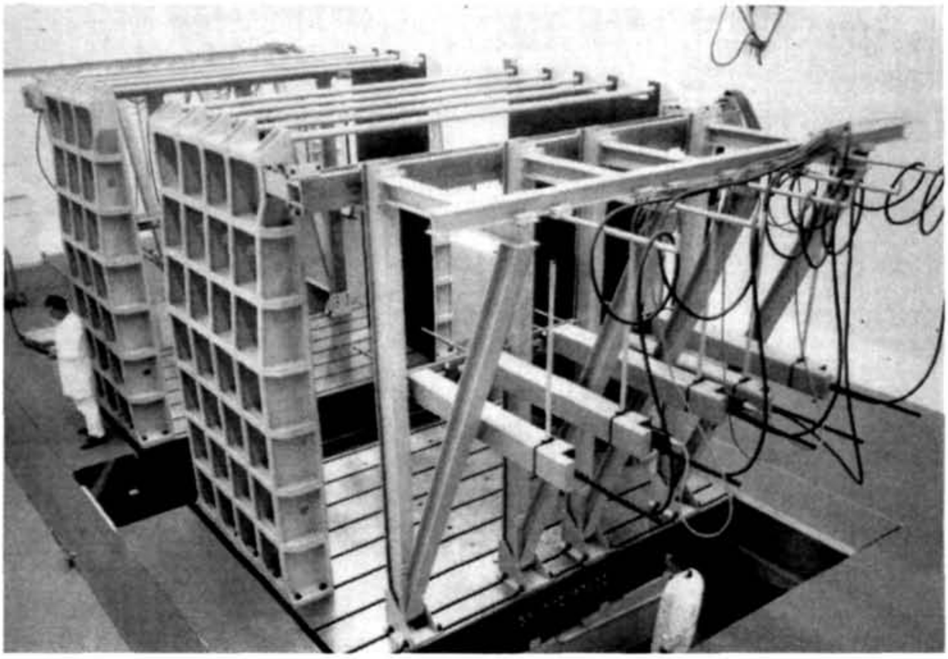

Figure 6-14 Critical Facility
P47 AAEC Annual Report 1972

The Critical Facility, according to Hardy, was a 'white elephant' and was never effectively used for the purpose for which it was built; research on reactor cores. '*It turned out to be difficult to get the required amounts of enriched uranium for the initial experiments. It was even more difficult to get sufficient quantities of plutonium ... Eventually, in 1987, the high precision split table and its associated equipment were scrapped and the building cleared so that a new major piece of equipment could be installed*'[210]. The Critical Facility was the government sweetener after the Jervis Bay fiasco and despite the cost of the facility, the government was happy to finance it. Yet, it too, failed to be the research tool required by the Commission scientists.

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