URANIUM AND THE ENVIRONMENT - CONSERVATION OR CURE?

notes from a paper delivered by

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at a Symposium

"IS URANIUM A POSSIBLE ALTERNATIVE TO MEET THE WORLD'S ENERGY SHORTFALL?"

PERTH, OCTOBER 1976.

BULLETIN No. 21.

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A B S T R A C T

The potential of utilisation of the mineral called uranium can be assessed on three factors:

(a) moral issues
(b) political issues, and
(c) environmental realities.

Resolution of factors (a) and (b) is an intensely personal one. It necessarily and understandably will be coloured by knowledge of the Nagasaki and Hiroshima nuclear explosions, subsequent underground and atmospheric nuclear tests, and also by debate about the potential of nuclear devices to hold individual countries or cities to "ransom" should such devices fall in the hands of terrorists or gangsters.

From an environmental point of view, experience has been gained, and confidence can be expressed, that nuclear powered devices, if used with adequate forward planning, can actually assist in the present "quality of life". However, the judgement as to whether we should provide that improved quality of life and a consequential potential heritage of hazardous nuclear wastes to future generations is strictly a moral issue. This issue has to be decided by the community at large. It is the scientists', the environmentalists' and the politicians' task to ensure that such a decision is based on facts.

Western Australia has no need to rush into uranium use. Quite clearly, we are at an advantage because decisions on such use can be based on a stockpile of fact - not a stockpile of waste. We can, and must, plan accordingly.

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INTRODUCTION

All the questions involved in nuclear debates cannot be answered here today (or anywhere) but what is important is that factual information is provided in the public arena for rational debate.

We are at this Seminar to try and determine whether we consider uranium - and by extrapolation, nuclear generated energy - a possible alternative to a projected world energy shortfall. The shortfall as we have heard already is a function of both depletion of readily accessible fossil fuels and of ever increasing demand. It has been said many times that alternatives to nuclear power such as nuclear fusion, solar, wind, tidal and geothermal have limited technological or economic factors at this stage.

Australia is at the crossroads in decision-making on future energy requirements. Australia is a "lucky" country with regard to its *fossil* fuel deposits and reserves. However, from an environmental management point of view it has to be recognised that the increasing speed of industrial and other development means that such reserves are utilised many thousands of times faster than they can be replaced. Accordingly there is a need for fuel and energy reserves to be made available to the public with a "time constant" responsive to the inevitable public demand. This country does have amongst the world's richest reserves of uranium. In addition the country has had in the order of twenty years' experience in controlled nuclear fission. This country established the Australian Atomic Energy Commission which has carried out its activities at Lucas Heights and accordingly may be looked to as an appropriate government body to advise on nuclear power. I don't propose to delve here into political or moralistic arguments but to concentrate on environmental issues associated with the nuclear power debate.

In discussing the role of uranium and the environment I intend to proceed sequentially. I will use first an illustration of which I had personal experience and where the use of a nuclear explosion without prior complete knowledge resulted in atmospheric devastation and in the loss of three high altitude satellites - at a cost of somewhere between 60 and 100 million dollars. It was an illustration of what can happen if one utilises the potency of nuclear power without a full understanding of the potential consequences.

I will then discuss studies that I have been personally involved in, concerning analysis of the potential radiation hazards to the Apollo astronauts due to terrestrial radiation belts and potential solar outbursts of protons and heavier nucleii.

From there I will proceed to a brief discussion of the controversy surrounding the visits of nuclear powered warships to Australian ports drawing in particular on the involvement of my Department in the recent visit of the U.S. nuclear powered submarine 'Snook'.

Then I will examine the contrast between the 1962 Starfish upper atmosphere nuclear explosion and the experience of a large number of power stations to illustrate the situation of understanding more and more about the environmental consequences of the use of nuclear devices.

Finally, I will discuss the potential role of uranium in generation of power which the human population demands and examine the question whether uranium and nuclear or other devices which have radioactive consequences really can be thought as having a positive role in minimising entropy and in conserving the natural environment, or whether indeed they are as some people claim a "sorcerer's apprentice" device likely to escalate to the point where the quality of life can be totally degenerated - from the physical environmental point of view, of course.

UPPER ATMOSPHERE NUCLEAR EXPLOSIONS

A great deal of controversy took place in 1972 regarding the upper atmospheric tests being carried out by France and China. In an address I gave to ANZAAS in Perth on 14 August 1973 I examined these matters in some detail and here I would like to precis some of the contents of the paper I presented and also the discussion that took place afterwards in a seminar atmosphere in which I was a guest speaker together with Professor Ernest Titterton and Dean Hazelwood.

I drew particular attention in my address to the 9 July 1962 Starfish explosion of 1.4 megatons of TNT equivalent, which was my first detailed professional study of nuclear explosives. On that date at 0300 hours GMT the United States exploded the 1.4 megaton nuclear device at an altitude of 400 km above Johnston Island in the Pacific. There had been strong criticism of the proposal to carry out such a large high-altitude test because some considered that it was not known for certain what the circumstances would be. Some experts in the United States who had been involved in the earlier 1958 upper atmosphere tests (which were conducted with bombs at lower altitudes) predicted that there would not be any significant problems great enough to argue against the Pentagon proposal to carry out the test in America's other interests.

At the ANZAAS symposium the discussion became - understandably enough - somewhat emotive. I made the point that in connection with upper-atmosphere nuclear explosions and indeed the use of nuclear devices generally there were three categories of objections that could be voiced. These were respectively:-

(1) Moral
(2) Political
(3) Environmental

I made the point furthermore that there is a very human and understandable desire to quantify arguments, or to put numbers to them, so as to attempt to assess whether they are good or bad. In the case of the first two categories, moral and political, quite clearly one cannot put numbers to the arguments. Only the third category, the environmental category, has the possibility of having numbers and therefore quantifiable arguments added to it.

I suggested then, and I suggest now, that a scientific audience and a general audience can be very clear in its own mind as to when it is using scientifically accurate environmental arguments and when it is using essentially social or moralistic attitudes.

In the first two categories of moral and political arguments the conflicts need to be resolved by each individual.

It is a concern of mine that through the desire of people to quantify their arguments and thereby direct them towards the avenue of environmental aspects (albeit coupled with cost benefit analysis and energy and entropy arguments) that there would be a deterioration in the quality of assessment of environmental parameters.

Indeed the fact that people have to quantify their assessment of environmental parameters and on occasion distort them with social or moralistic attitudes does concern me.

It concerns me not because of the social or moralistic attitudes which are an aspect of individual and private decision. It concerns me on the broader base. The popularity of other environmental comments and assessments could be unduly distorted without quantitative and scientifically justified facts.

APOLLO RADIATION STUDIES

When it was proposed that American astronauts should travel to the moon, scientists were learning more and more about the geomagnetically trapped radiation around the Earth. Initial estimates grossly over-estimated its radiation hazards due to misinterpretation of geiger counter data and the assumption that high counting rates were due to *Bremmstrahlung* from one million electron volts (1 Mev) electrons of a very high flux whereas in fact they were due to direct penetrating high energy electrons with a very low flux.

Nevertheless the potential hazard from the geomagnetically trapped radiation had to be assessed since there was no practical way that an astronaut on his way to the moon could avoid penetrating the Van Allen belts. More problematical of course was the fact that at the time in the early 1960s we were well aware of the fact that the sun sporadically emitted vast clouds of high energy protons which would penetrate the spacecraft and expose the astronauts to intense radiation.

I was one of three scientists who was assigned by the U.S. National Aeronautics and Space Administration to assist them in determining whether indeed astronauts could safely travel to the moon and how they could do so in view of the essentially constant hazard from the geomagnetically trapped radiation and the sporadic hazard from solar eruptions.

We spent several years on the study and in the end came to the conclusion that from a physical scientific point of view we knew far more about what the radiation levels were likely to be, than the medical practitioners knew what the effects of such radiation on humans would be. This is perhaps epitomised by the fact, after a very lengthy discussion carried out with medicos and astronauts in Houston, Texas, about radiation hazards, one astronaut (who was subsequently killed through other factors) stated "I am not concerned about radiation hazards that would produce genetic damage, I want to know what radiation level will cause me to vomit so that I choke inside my space helmet."

This is one aspect of radiation versus medical health that the physical scientists continually confront - it is one where there is a great deal of uncertainty and a great deal of contradictory evidence. One of our specific scientific problems in this particular assessment for the astronaut programme was that much of the then-existing data was based on genetic and other damage caused by X-rays and gamma-rays, rather than by ionizing nuclei.

In 'Science' recently there was, for example, a statement in an editorial by Finch and Hamilton to the effect that there is no evidence whatsoever of genetic damage to the second generation of those affected by the Nagasaki Hiroshima nuclear blasts. There is however, evidence of continued susceptibility to cancer, even 30 years after the explosion.

It is all very well for the physical scientists and the physical environmentalists to give us the numbers, but it is quite clear that at the present time there still is an emotive uncertainty associated with what the actual effects of radiation, (i.e. ionising radiation) may be on the current population and genetically perhaps through mutations on future generations. The reports appear to indicate at the moment from the intense exposure of Nagasaki and Hiroshima that this is a first generation problem only and not a second generation problem. I am not qualified to treat this matter in detail, but I certainly wish to draw the attention of this Seminar to an aspect about which a great deal of emotive writing has taken place.

VISITS OF NUCLEAR POWERED WARSHIPS

Since 1971 until recently there was a restriction on the visit to Australian ports of nuclear powered warships. Early in 1976 with the change of government in Canberra the possibility arose that there would be a review of this Australian policy and that for various reasons in the national interests associated with defence and diplomacy it might be deemed appropriate that nuclear powered warships should gain access to Australian ports.

Discussions were held between State Government officers and equivalents in the Federal Government. The Prime Minister and the W.A. Premier jointly announced early in June 1976 their agreement that U.S. nuclear powered warships could use the Cockburn Sound naval facility, currently at an advanced stage of construction.

Quite clearly in this case it was judged by the political powers that defence and other interests were such that it was desirable to have nuclear powered warships visit Australian ports under strict controls in association with either defence exercises or rest-and-recreation exercises.

The first port chosen in Australia for the renewed visitation by nuclear powered warships was Cockburn Sound and it fell to my Department, and my Departmental officers, to arrange in collaboration with other State and Federal agencies sufficient evaluation of the environmental safeguards and monitoring required such that visits should be able to take place without undue perturbation environmentally or socially.

The U.S. submarine 'Snook' subsequently visited Cockburn Sound between Saturday 14 and Thursday 19 August 1976 and a very extensive monitoring network was established to ensure that radiological hazards, if present, could be rapidly detected and preventitive action consequently taken.

The visit, with the cooperation of the Australian Atomic Energy Commission, the State Public Health Department the Fremantle Port Authority and others, went off with no mishaps.

We have available public documents (which are not prone to problems of security classification) which indicate the general situation as pertains to visits by nuclear powered warships to Australia. More important for Western Australia, the specific Western Australian programme of monitoring and surveillance and remedial operation measures in the event of an untowards accident or happening are listed. These documents are available in public libraries and the Reading Room of the Department of Conservation and Environment at BP House, 1 Mount Street, Perth.

The visit of the 'Snook' went off with little particular perturbation from the public or from trade unions even though there had been significant prior speculation as to such perturbations occurring. I attribute the smoothness of the visit in large part to the fact that we ensured that there was no possibility of any scientific criticism of the monitoring and detection capabilities that were established, nor of the emergency programmes that hopefully, would not, and in fact were not, brought into play. In other words, safeguards were organised - but not needed.

In the case of the 'Snook' therefore (and I would envisage in the case of future visits) there was sufficient precedent and sufficient experience to enable us to plan scientific monitoring programmes in the event of an unlikely accident and the whole process was carried through quite satisfactorily. This is of course in distinct contrast to the first example I cited of the Starfish nuclear device where basically we had not very relevant precedent with which to have advice proffered to the U.S. Government.

The simple facts were that we had inadequate experimental and proven knowledge to advise the U.S. Government as to what should be done about the proposed Starfish explosion, but we did have such knowledge in the case of the 'Snook'.

It is an important point of this paper that the relative lack of knowledge and lack of experience associated with Starfish is not commensurate with present knowledge and experience in proposals for utilisation of nuclear power in Australia.

Decisions made on utilisation of nuclear power in Australia and such aspects as export of uranium in various forms should be made in the light of technical appreciation of the potential benefits and hazards of such actions, updated as new knowledge is required.

NUCLEAR-POWERED STATIONS

There is little doubt, technically, that man can design and build nuclear powered stations which are safe to currently acceptable criteria and have "acceptable" environmental impact under normal operational conditions.

There have been accidents involving radiation and support facilities and people have been killed. (See Patterson, 1976, for example).

Such statements as "there has never been a radiation injury to anybody in a commercial nuclear power plant nor has there been any instance in which these power plants have affected public health or safety"* are true, but do little to appease concerned persons who know that this may not necessarily be correct for say, a non-commercial plant.

What is needed is not carefully worded statements by proponent or critic but an examination of the facts as known - a clear delineation of the alternatives so rational debate can take place and political decisions taken in this light.

The nuclear debate revolves around a choice.

At the current state of knowledge it does not seem possible to reconcile present living standards and social structure (and associated energy-hungry technology) with non-nuclear energy sources for the next few decades at least. The choice to be made will determine life-styles for the future. If the present life-style is chosen to continue then it is inevitable that nuclear-generated energy will be necessary to sustain it over the next decade of planning. If nuclear power has an essential risk factor no matter what dimension, then that is also part of the choice of the community as it chooses its life-style.

* From an Australian Atomic Energy Commission pamphlet "What is Nuclear Power?"

The population of the world and of Western Australia has to decide *inside itself* what benefits it hopes to accrue from nuclear energy utilisation and what potential disadvantages may also arise. The present thrust of public comment is such that rational utilisation of nuclear potential in Western Australia will become essential - indeed the lack of utilisation of this particular mineral resource could validly be seen as an incompetent exercise in planning.

But as I have repeated, the decision needs full factual background. On the environmental side - while more and more data are gathered on effects of nuclear power plants - clearly it is now impossible to know all the impacts at the planning and decision-making stage.

Again a value judgement is involved. The Ranger Uranium Inquiry under Mr Justice Fox is nearing the end of its deliberations and will make recommendations to Government in the light of the most complete assemblage of data on these issues in Australia. It is presumptuous to try and predict the recommendations. But I can outline some of the environmental issued involved.

There are many intermediate steps between finding an uranium-ore body and receiving electric power from a nuclear power plant; and they all have significant environmental aspects. Consider mining and processing the ore. There are human-health problems such as the potential inhalation of the inert radioactive gas Radon - 222. That problem was first recognised during medical investigations of underground miners in Joachimstral, Germany in the 1930s. They were working pitchblende deposits for radium when an unusually high incidence of lung cancer was noticed. The cause was inhalation of dust particles to which electrically-charged radioactive elements were attached. This problem has now been well documented (Patterson, 1976) and appropriate precautions taken to ensure adequate ventilation and air filtering. Uranium tailings' disposal is also an environmental problem (Pohl, 1976). Special care is needed to ensure radioactive contamination does not occur especially through leaching processes.

The point is that there are inherent risk factors in all commercial forms of power generation. What we can ensure is that the tightest possible control is placed over reactor design, construction and operation with the additional knowledge gained by some 25 years of nuclear power generation. This contrasts with the case of Starfish mentioned previously, when the nuclear device was exploded in relative ignorance of environmental effects.

Thermal pollution by nuclear power stations is one environmental issue not directly debated on radioactivity grounds. It is true to say that the use of both air and water for large-scale cooling of nuclear power plants has considerable environmental impact. But the impact needs discussing. It may be acceptable to have a rise in water temperature and have say one species of aquatic fauna replaced by another. Only study of the particular proposal and existing environment could say. There is obvious need to minimise impact but it is clear that a compromise can be reached in terms of benefits. Certainly on this particular aspect it is arguable that alternate energy sources including fossil fuel can often have greater environmental impact, e.g. damming for hydro-electric power on water cycles and systems, SO2 and ash fall-out from fossil fuel plants on air pollution, etc.

If all the arguments concerned with nuclear power and the environment those concerned with nuclear waste management are among the most bitter.

Nuclear-waste management presents man with a major technological problem. The waste is accrued from fuel residues and reprocessing plants and is strongly radioactive and some is long-lived. The disposal of such waste is a major environmentally significant problem of the nuclear power process. Various methods have been used in the past and a number have been proposed for the future including such things as transportation by rocket to the sun and concealment in the polar ice caps (which, frankly, I consider ridiculous). The question of whether we should leave this waste for future generations to inherit is another essentially moralistic judgement.

Some nuclear reactors require enriched fuel to sustain a chain reaction (i.e. increasing the content of U^{235} above the normal 0.7%) and the enrichment plants require stringent environmental safeguards. The most common technique used is gaseous diffusion of UF_6 through semi-permeable membranes with the lighter $U^{235}F_6$ diffusing slightly faster than the heavier $U^{238}F_6$. The safeguards which have been developed include special provisions for the corrosive nature of the gaseous uranium hexafluoride. The developing fast-breeder reactors may in time reduce the need for large quantities of enriched uranium. In that sense, alone, they may be thought of as "conservation" oriented.

Nuclear power generation has a number of important environmental considerations associated with it. Broadly speaking three major concerns are:

(a) Safeguards against radioactive emission routinely or by accident;

(b) Thermal pollution by cooling systems;

(c) Radioactive waste management.

Safeguards against radioactive emission during routine operations has come a long way since the first Fermi "pile" went critical in a disused squash court in Chicago. Sufficient data exist now to ensure during design that levels above prescribed limits do not occur. Accidental discharge is another matter.

But accidents themselves are not exactly unknown in any power generation and with hindsight, the experiences of mishaps to date in nuclear power plants have in fact added substantial knowledge to prevent any other similar occurrence. This does not mean I support nuclear accidents as useful learning tools! The additional knowledge and experience gained during "near misses" has, however helped to reduce the chances of future accidents.

The judgement of any generation to produce technological devices, and improvements in the technical quality of life for that generation, which may result in leaving for future generations waste or an environment of poorer quality of one form or another, is a decision that has to be made by the community at large. It cannot be decided by any single individual because of his highly personal involvement in his feelings for potential future generations.

Environmentally, if faced with this problem of nuclear-waste management, assurance against all forms of leakage would need to be an obvious part of the design. Should Western Australia or Australia decide to "go nuclear" in the future it is to be hoped that some of these problems associated with nuclear-waste management would be solved. One technique developing in the U.K. is the vitrification of the toxic wastes in glass which would eliminate the chance of waste in liquid from leaching from containment. There is no opportunity in this short comment to treat such aspects in technical detail.

CONSERVATION OR CURE?

The energy shortfall, which has been analysed in depth by previous speakers, leaves the dilemma of supplying the interim energy demand until "cleaner" or allegedly cleaner alternatives are developed. We have been told that technologically and economically, nuclear power is the only suitable alternative at this stage. However, there has been intensive debate as to its environmental acceptability. I believe that it can be acceptable - with these provisions:

(a) The greatest care in design and running of nuclear power stations be exercised to ensure the utmost safety.

(b) Development of environmentally satisfactory nuclear-waste management techniques.

(c) Maximum effort being employed in developing environmentally cleaner long-term alternatives and that nuclear fission power stations be phased out over time.

As I have previously said, it would be presumptuous to foreshadow Mr Justice Fox's findings of the Ranger Enquiry. Obviously his report will have a major effect on the Commonwealth Government's decision whether or not to allow,inter alia, the export of uranium in the future. However, in terms of conservation there are two points: Whether or not to conserve the resource for ourselves or whether the mining of uranium threatens the conservation of the natural environment. It is this second point I wish to explore a little further here. Firstly there are very few mining operations which don't significantly affect the environment. This is a condition of supplying our demand for that resource. In this State, mining companies generally recognise their responsibility to the environment and act accordingly.

With appropriate safeguards as I have previously mentioned, there is no reason why uranium mining should be penalised above any other mining operations on environmental grounds.

The emotive response of most of the population to uranium and nuclear powered processing is understandably associated with the devastating power of the atomic bombs that wreaked such havoc in Hiroshima and Nagasaki during the final stages of the Second World War. The effects there were truly tragic. However, we cannot let our emotions or concern about those events and indeed our concern about potential major power nuclear warfare or even terrorists' groups' minor acts of power with uranium or nuclear devices overcome the necessity for forward planning of the most efficient and least disruptive power-generating sources.

It has yet to be proven that uranium-powered devices satisfy these requirements, although the evidence is steadily mounting in that regard.

We cannot afford the short-sighted luxury of adopting a posture of "stop the world I want to get off" until solar power utilisation, tidal power utilisation, or other nominally clean power generators are brought to the point of efficiency and cost-effectiveness. Society, if it feels strongly enough about the moralistic issues of the exploitation of nuclear power, has to accept that in the next few decades it may be lacking the amenities of its freezers, its refrigerators, its electric frypans, its colour televisions and the like, simply because the requisite energy resources are not available.

In the broader sphere of how the quality of life may degenerate from a physical environmental point of view if large-scale generation of nuclear power was adopted, the issues are debatable, as this Seminar indicates. The fundamental scientific fact of generation of electrical power is that it cannot achieve one hundred per cent efficiency. It therefore produces waste products.

A cost-benefit study of the various alternatives will need to be adjusted depending upon the area of the world and the local resources, weather and the like.

Western Australia is obviously an ideal candidate for development and utilisation of solar power. Perth has been declared to be the windiest city in Australia and hence there is promise that wind-driven generators with supplementary buffer batteries could be an important source of energy for small localised areas.

However, the uranium potential and indeed the massive potential industrial development in W.A. are such that one should make plans right now for utilisation of nuclear energy.

The moral decision which has to be faced by our political leaders is not so much potential hazards for the present generations, because experience has shown that these can be controlled and made safe using the present technological experience. The moral question really is as to whether we leave to generations yet unformed the problem of coping with nuclear wastes. I believe that we can do so --

but only

if there is, built-in to such developments at their formative stage rigid and reliable environmental assessment and monitoring procedures. We would be irresponsible otherwise.

CONCLUSION

W.A. should 'go nuclear', but we must have adequate control and management. I am confident that we can do so. The 'magic' nature of Western Australia need not - and should not - be lost.

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