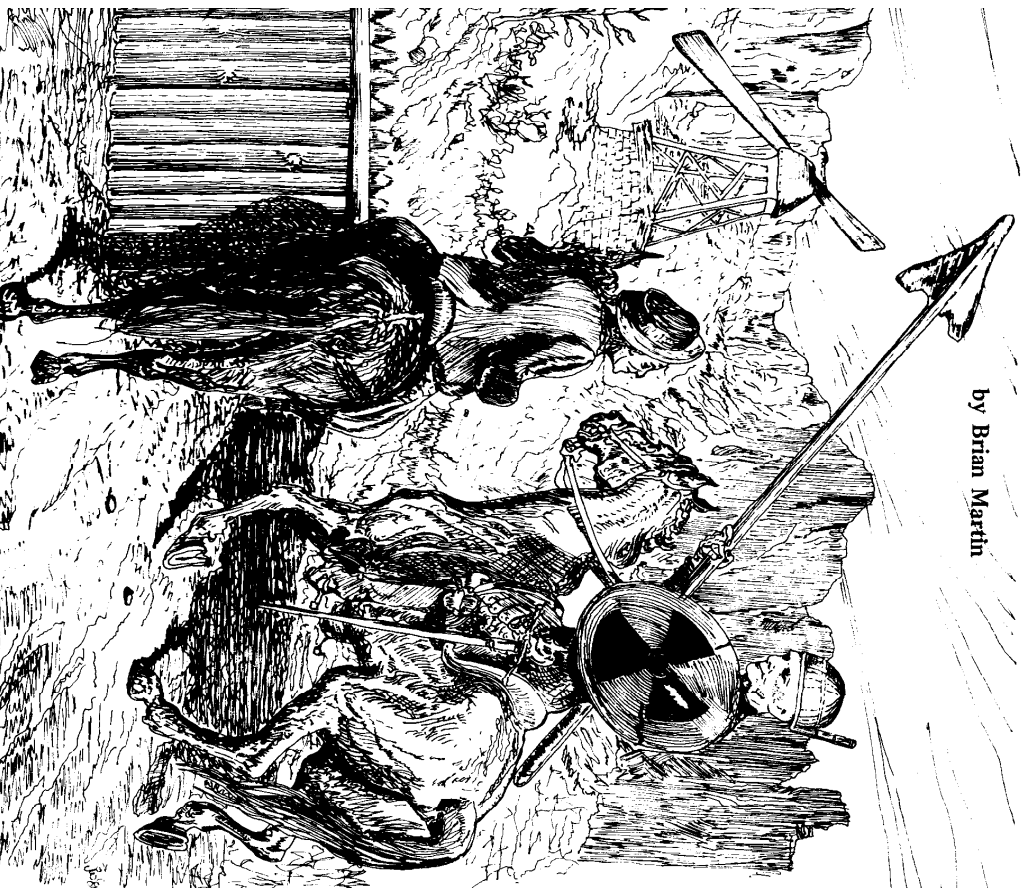


NUCLEAR KNIGHTS

by Brian Martin



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Also by Brian Martin:

The Bias of Science

Changing the Cogs: Activists and the Politics of Technology

First published 1980 by Rupert Public Interest Movement Inc., P.O.Box 346, Dickson ACT 2602, Australia.

Printed by Union Offset Co. Pty. Limited, Fyshwick ACT, Australia.

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National Library of Australia card number and ISBN 0 9595025 0 5.

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ACKNOWLEDGEMENTS

The following kindly granted permission to use photos and graphics: South Coast Register Pty. Ltd., Nowra, for use of the cartoon on page 19 from the *South Coast and Southern Tablelands Magazine*; *Chain Reaction* for use of the photo of Sir Philip on page 6; the *Canberra Times* for use of the photo of Sir Philip on page 41 (copyright held by the *Canberra Times*); Sir Ernest Titterton for use of the photos of Sir Ernest on pages 6 and 21 (copyright held by Sir Ernest Titterton); Matt Mawson and *Social Alternatives* for use of the cartoon on page 38.

For valuable help, I thank Marie Cook, Michael Cook, Ruth Cook, Alan Cummine, Mary Featherston, Joan Henry, Margaret Anne Jones, Beryl Key, John McMillan, Graeme Morris, Ann Moyal, Katherine Pitt, Hugh Saddler, Stewart Toshack, Pat Turner, George Vorlicek and Peta Watt. Special thanks go to Betty Hawkins for extensive proofreading, to John Wood for graphics, and to Mark Diesendorf and to Rosemary Walters for their numerous detailed comments. Typesetting facilities kindly were made available by the Australian National University Students' Association.

I take responsibility for the accuracy of all statements in this study. Comments, criticisms and suggestions are welcome, and may be sent care of the publishers, Rupert Public Interest Movement Inc.

— Brian Martin, September 1980

FOREWORD

When the dividing line between government policies and those who support them becomes blurred the accountability of both commands our attention. One area in particular where this symbiosis is habitual is where governments choose and justify policies of technological change by reference to expert technical opinion expressed by the government's scientific advisors and supporters.

Governments and scientists have benefited alike from this process. The resort to science in political decision-making provides governments with a conclusive answer, namely that experts have insisted that a technological initiative is necessary, economically sound, and safe. The answer fits well on the other hand with the self-esteem of scientists — that experts can be trusted, since theirs is a precise and self-contained discipline. Both groups share the supplementary advantage that direct consideration of moral or social assessments is evaded — a process that could be damaging to one and threatening to the other.

Such a process, which pits science against democracy, has prevailed in the development of nuclear policies. Reasoning from the assumption of a world energy crisis, the Australian Government has been quick to conclude that experts alone can solve the problem. Yet, as a vocal army of critics — scientists and laypeople — now claim, energy and nuclear energy are much else besides technical issues. More fundamentally, they raise questions of radioactive pollution, escalation of an arms race, restrictions on civil liberties, and possibly the survival of life itself.

Brian Martin's book is about this dilemma as it is evidenced in Australia. Therefore the study rightly focusses on two men: distinguished scientists, public figures, nuclear protagonists, government advisors — two knights honoured for their service to Australia.

Yet Dr Martin's book does more than examine the case presented by Australia's two leading proponents of nuclear technology. It questions in addition the widespread acceptance of the neutrality of science and technology, the interaction between governments and scientific elites, the compatibility of the roles of scientist and public advocate, and the degree to which scientists' public stances serve to enhance their own professional status.

Rupert Public Interest Movement, itself committed to ensuring that views touching upon issues of public interest do not go unheard, believes this objective is excellently served by Brian Martin's book.

— John McMillan, Secretary, Rupert Public Interest Movement

INTRODUCTION

Sir Ernest Titterton and Sir Phillip Baxter have been by far the most prolific public advocates of nuclear power in Australia. The following analysis of their views has several aims:

- to uncover the assumptions and associated values on which their cases are built;
- to investigate links between their views and their professional and social positions;
- to spell out ways in which the choice and structure of their arguments serve to mould their internally self-consistent viewpoints.

It is well known that the views of most people — such as farmers, executives, doctors, builders, labourers and politicians — are influenced by their social and occupational positions. It is expected that, for example, automobile manufacturers will support road-building programmes. But it is sometimes believed or claimed that scientists are different, and that they adopt neutral, objective responses to issues.

It may be asked, then, are the views of Sir Ernest and of Sir Phillip neutral, objective responses to the issues of nuclear power? Or can their views be predicted from basic themes or goals which are closely linked with their professional positions as nuclear scientists? It is such questions that are addressed in this analysis.

The main purpose here is not to reply directly to the arguments and claims of Sir Ernest and of Sir Phillip. In any case, arguably, their cases have already been refuted on a number of occasions¹. Rather, the primary aim of the analysis here is to serve as a guide for making sense of the public views of Sir Ernest and of Sir Phillip.

Also, this is a study of published, written views and not of psychology². Nothing here should be taken to imply conclusions about the motivations or thought processes of Sir Ernest or of Sir Phillip. Almost all people have the best of intentions³, and there is no reason to think Sir Ernest or Sir Phillip differ from the norm in this regard.



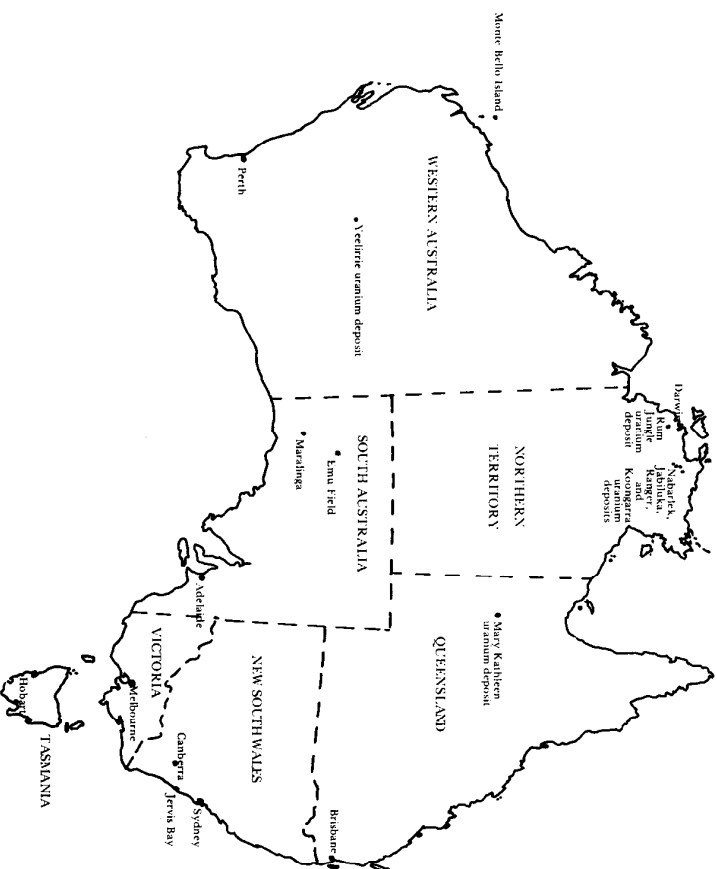
Sir Ernest Titterton



Sir Phillip Baxter

It should be noted that the author has been a public opponent of nuclear power. Although every effort has been made to avoid being unfair, the author's position of opposition to nuclear power should be kept in mind in assessing this analysis.

Before turning to the detailed analysis of the arguments and claims of Sir Ernest and of Sir Philip, some general introductory material will be presented: a brief account of the context of the nuclear debate in Australia, to provide perspective; a brief summary of the case against nuclear power as presented by opponents of nuclear power in Australia, to provide a gauge for judging the emphases placed by Sir Ernest and by Sir Philip; and a brief survey of the public proponents of nuclear power in Australia.



1. CONTEXT OF THE AUSTRALIAN NUCLEAR DEBATE

1.1 Historical development⁴

Serious exploration for uranium in Australia began in response to the development of nuclear weapons during and after World War II. A number of mines were operated in the 1950s and 1960s, notably at Rum Jungle in the Northern Territory, under the control of the Australian Atomic Energy Commission (AAEC) which was established in 1953. Also aiding the British nuclear weapons programme were twelve nuclear weapons tests in Australia in the 1950s, at Monte Bello Islands off the northwest coast, and at Emu Field and Maralinga in South Australia. The AAEC constructed two research reactors at Lucas Heights near Sydney, and built up a large technical and research staff.

In October 1969 the then Prime Minister John Gorton announced plans for a 500MW nuclear power reactor at Jervis Bay. However, as a result of various developments and pressures, especially economic cost, the proposal was dropped within a few years⁵. The years 1972 and 1973 saw the first significant public debate over a nuclear-related issue, namely French nuclear tests in the Pacific.

Because of its abundant supplies of low cost coal, nuclear power has never been a serious economic option in Australia. The major debate arising out of nuclear power has focussed on the mining of uranium, sizeable reserves of which were found in the Northern Territory in the early 1970s. Until 1975 the advisability of uranium mining was virtually unquestioned by industry, government bureaucracies, political parties, unions and the general public. However, the Labor government in July 1975 set up a wide-ranging inquiry into uranium mining at the Ranger deposit in the Northern Territory. It was influenced to do this by concern over Aboriginal land rights, by the existence of recently passed environmental protection laws, by willingness to wait for higher uranium prices, and by growing pressure from some sections of the public and of the Australian Labor Party itself. The Liberal-Country Party government which suddenly took power in November 1975 was fully committed to uranium mining, but waited before announcing its decision for the reports of the Commission conducting the inquiry, which were made in October 1976 and May 1977⁶.

During this period there was a great increase in the public debate over uranium mining and nuclear power, notably in the scale of news coverage, distribution of information, speeches and films sponsored by advocates on either side. Besides the information campaign, the opponents' efforts included a national signature drive, demonstrations and marches, an annual bicycle 'Ride Against Uranium' and various lobbying efforts. Most of this was accomplished through a great many local citizen action groups. As a result of grass-roots concern and initiative at the local party branch level and in individual unions, in mid 1977 both the Australian Labor Party and the Australian Council of Trade Unions adopted stances expressing opposition to uranium mining. These policies were reaffirmed in 1979. The efforts of proponents of uranium mining were marked by an expensive press and television advertising campaign under the auspices of the Uranium Producers' Forum, a body formed by leading companies with stakes in uranium mining.

In August 1977 the Liberal-National Country Party government announced the go-ahead for uranium mining⁷, with the condition that strict export policies be adopted to prevent proliferation of nuclear weapons capabilities, and with the requirement that traditional Aboriginal landowners be consulted before mining commenced. This latter process was long and difficult and involved a great deal of controversy⁸. Work at the uranium deposits at Nabarlek, Ranger and Yeelirrie began in 1979, with actual export from these mines being unlikely before 1981. Public debate on nuclear issues has continued, with a gradual widening to encompass energy issues in general.

1.2 The case against nuclear power and uranium mining

It is useful to summarise briefly the main arguments used in Australia against uranium mining and nuclear power, both to put the Australian nuclear debate in perspective and to highlight the case with which the Australian nuclear advocates have been confronted in public. The case against nuclear power and uranium mining in Australia has been concerned, mainly with environmental, political, economic, social and cultural impacts of nuclear power, with shortcomings of nuclear power as an energy source and with presenting an alternative energy strategy⁹. The order in which these themes are listed here is not necessarily an indication of relative importance.

The environmental hazards of greatest concern are reactor accidents, releases of radioactivity in various stages of the nuclear fuel cycle and

radioactive waste. Reactor accidents have not received nearly as much attention in Australia as elsewhere, no doubt because Australia has had no realised plans for nuclear power reactors. Significant attention has been focussed on releases of radioactivity in the fuel cycle, particularly during uranium mining, on the hazard of plutonium and on the possibility that low-level ionising radiation is more harmful than officially recognised. Also of great concern has been the problem of long-lived radioactive waste. The Ranger Inquiry's statement that "There is at present no generally accepted means by which high level waste can be permanently isolated from the environment and remain safe for very long periods"¹⁰ has epitomised the basis for concern on the waste issue.

The foremost political impact of nuclear power is its potential contribution towards proliferation of nuclear weapons. The Ranger Inquiry stated unequivocally "The nuclear power industry is unintentionally contributing to an increased risk of nuclear war. This is the most serious hazard associated with the industry."¹¹ Because of Australia's role as a potential uranium exporter and not a user of nuclear power, the proliferation issue has received great attention, comparatively much more than in most other countries. Another political impact often raised is the possibility of terrorist or criminal use of nuclear materials.

Due to the potential environmental hazards, proliferation potential and possibilities for terrorist and criminal use, the threat to civil liberties posed by nuclear power has been of concern¹². This has been especially significant in Australia since the government gave the go-ahead for uranium mining under a body of highly restrictive legislation, notably the Atomic Energy Act which was originally used for acquisition of uranium for the British nuclear weapons programme. These laws for example include the possibility of stiff fines and gaol sentences for even speaking out against uranium mining¹³. These powers have not been used but are considered ominous.

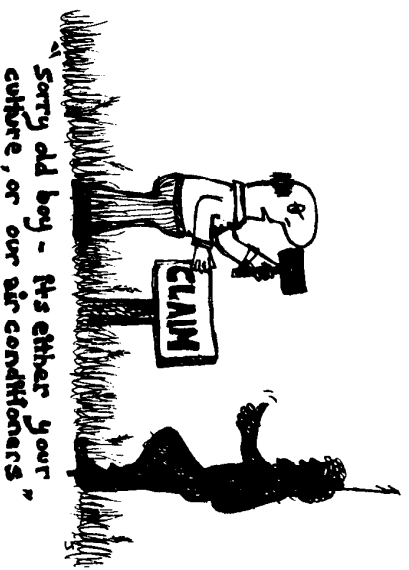
Concerning economics, an issue has been made of the large and rising economic costs of nuclear power¹⁴ and of various subsidies which have been made to it such as exemption from full insurance for nuclear accidents. Opponents have argued that the expected returns and export income from uranium mining, while large from the viewpoint of the mining companies, are small on a national scale¹⁵. Opponents have also argued that uranium mining export income is not likely to be as large as predicted by the companies, that returns are unstable in the light of slowdowns in the worldwide nuclear industry¹⁶, that much of the profits will go overseas and

that many more jobs would be created through alternative investments¹⁷.

In terms of social impacts, it has been argued that nuclear power would lead to less security for people due to its environmental dangers, increased proliferation potential and scope for terrorist and criminal activities. Also, because of the enormous investments in nuclear power and the need for large organisations and experts to guard against these possibilities, it has been argued that nuclear power leads to a centralisation of political and economic power. Powerful corporations, government bureaucracies and professional groups with a stake in nuclear power would, it has been argued, oppose any move away from nuclear power¹⁸ and hence reduce the scope for democratic involvement in decision-making about energy futures¹⁹.

Another vital concern has been the detrimental cultural impact which uranium mining, particularly in Australia's northern Territory, would have on local Aboriginal communities. This impact is due to the violation of sacred sites and of the land itself and due to the destructive impact of the influx of whites and white culture on Aboriginal culture, especially through sexual exploitation, alcoholism and breakdown of traditional relationships²⁰.

Turning to the question of how energy needs are to be satisfied, it has often been pointed out that nuclear power at present provides only about 2% of world primary energy and so is not yet an essential source. Furthermore, it is argued that nuclear power cannot contribute much to the real



energy 'crisis', an impending shortage of low cost liquid fuel mainly for motor transport, because nuclear power provides only electricity. Even the feasibility that massive nuclear power programmes could cater for ever-growing energy use has been questioned, on the basis of shortages of capital for building nuclear facilities, the long delay between planning and completing nuclear power plants and the slow rate at which plutonium is produced in fast reactors²¹.

The nuclear opponents' own proposals for a non-nuclear energy strategy have mainly followed the case presented by Lovins²², in which conservation and prudent use of fossil fuels satisfy energy needs while a transition is made to greater use of renewable energy sources in a highly energy-efficient society. Attention has also been focussed on life style changes and institutional changes such as better public transport, improved facilities for cyclists, and town planning to reduce transport needs²³.

Special attention has been drawn to the situation of the poor countries of the world. It has been argued that nuclear power is completely unsuitable there because of the shortage of capital and skilled labour, the lack of an electrical infrastructure and the gross inequalities between rich urban elites and the rest of the population. It has been argued that primary emphasis should be placed on local energy technologies such as biogas generators, wind-powered water pumps and more efficient stoves²⁴.

Of course opponents of uranium mining and nuclear power differ greatly in the emphases they place on the different arguments and issues. Summarising nevertheless, the case of the opposition can be classified into seven major themes:

- environmental hazards arising from the nuclear fuel cycle;
- proliferation of nuclear weapons capabilities via expansion of the nuclear power industry;
- political and social threats and restraints of a nuclear society (terrorism, reduction in civil liberties, centralised political and economic control);
- economic and employment disadvantages of nuclear power;
- impact of uranium mining on Aboriginal culture;
- inadequacy of nuclear power as a solution to energy problems;
- advantages of a 'soft energy path' based around conservation and renewable energy technologies.

While much of the opposition in Australia began and remains centred around environmental hazards, the other themes have attracted an increasing amount of attention and concern.

1.3 Australian public advocates of nuclear power

Table 1 lists most of the individuals who have been prominent in the Australian public debate over uranium mining and nuclear power on the pro-uranium, pro-nuclear side. Individuals included in the table are those who have written articles or significant numbers of letters for newspapers or wide circulation magazines, been nationally reported for their views favouring uranium mining and nuclear power, or otherwise featured prominently on a national level in the public debate over uranium.

Table 1 thus lists those who justifiably might be called public advocates of nuclear power, namely those who have made special efforts to promote uranium mining and nuclear power in the public debate. Even among this group there is considerable variation in the degree and form of the advocacy.

Table 1. Advocates of uranium mining and nuclear power prominent in the Australian public debate, listed in alphabetical order with their positions and main involvement in the debate.

Professor Heinz W. Arndt, Head, Economics Department, Research School of Pacific Studies and Deputy Chairman of the Institute of Advanced Studies, Australian National University, wrote an article²⁵ which has been often reprinted and quoted.

Sir Phillip Baxter, retired, formerly Chairman of the Australian Atomic Energy Commission and formerly Vice-Chancellor of the University of New South Wales, has written numerous articles in journals and letters to newspapers, given many speeches and often had his views reported by the media.

Mr A. Bicevskis, Leader, Risk Analysis Section, Engineering Research Division, Australian Atomic Energy Research Establishment, has written letters to newspapers.

Professor Stuart Butler, Director of the Australian Atomic Energy Research Establishment and formerly Head, Theoretical Physics Department, Sydney University, *Mr Robert Raymond*, journalist, and *Professor Charles Watson-Munro*, Head, Plasma Physics Department, Sydney University, wrote a book on the nuclear issue²⁶.

Mr A. J. (Tony) Grey, Chairman, Pancontinental Mining Ltd, has written letters to newspapers and had his views reported by the media.

Only three (Sir Phillip, Kemeny, Sir Ernest) have written more than the odd article for newspapers, and only one other besides these (Grover) is a major letter writer on a national scale.

Omitted from Table 1 are a few individuals whose views on nuclear power have received national coverage in a way supportive of uranium mining and nuclear power at least in certain ways, but who have not been so uniform or unqualified or open in their stances. In particular, Sir Macfarlane Burnett (biologist, retired) and Sir Mark Oliphant (nuclear physicist, retired) have each received press coverage of their views on the nuclear issue because of their prestige as scientists. Each has voiced strong reservations about the wisdom of nuclear power but each has in recent years supported the mining of Australian uranium²⁷.

Mr John C. Grover, Manager, Special Projects, Peko-Wallsend Ltd, has written numerous letters to newspapers and given many speeches.

Mr Lang Hancock, West Australian mining magnate, has had his views reported by the media.

Dr Don J. Higson, Head, Safety Studies Section, Nuclear Plant Safety Unit, Regulatory and External Relations Branch, Australian Atomic Energy Commission, has written letters to newspapers.

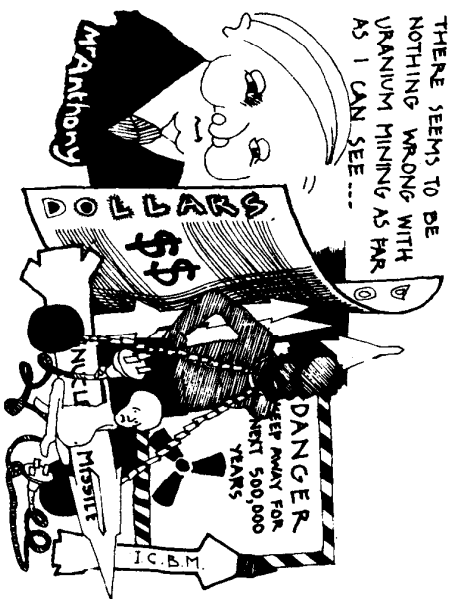
Mr Tim A. Hooke, Exploration Development Officer, Geopeko Ltd, has written letters to newspapers.

Mr Leslie G. Kemeny, Senior Lecturer in Nuclear Engineering, University of New South Wales, has written numerous articles in newspapers and letters to newspapers, and given speeches.

Mr George A. Mackay, Managing Director of Electrolytic Zinc Company of Australasia Ltd and Chairman of the Uranium Producers' Forum (now disbanded), has written letters to newspapers and made public statements reported by the media.

Professor A. E. (Ted) Ringwood, Director, Research School of Earth Sciences, Australian National University, has had his views reported by the media.

Professor Sir Ernest W. Titterton, Head, Nuclear Physics Department, Research School of Physical Sciences, Australian National University, has written numerous articles in newspapers and letters to newspapers, given many speeches and often had his views reported by the media.



One possible set of additions to Table 1 is politicians who have publicly supported uranium mining and nuclear power. Most noteworthy in this respect is Deputy Prime Minister J. D. (Doug) Anthony, who is also Minister for Trade and Resources and leader of the National Country Party. There are also a number of others in this category, such as Prime Minister Malcolm Fraser and the Premier of Western Australia Sir Charles Court. Other possible additions to Table 1 might be the occasional pro-nuclear visitors to Australia such as Edward Teller.

There is some degree of judgement involved in deciding which of Australia's less active nuclear proponents (such as Hancock and Higson) 'qualify' to be included in Table 1. However, there is little doubt that the pro-uranium and pro-nuclear case in the public debate has been dominated by those listed. Furthermore, the bulk of the impact has come from a subset of those in Table 1.

This may be illustrated by surveying the pro-nuclear letters and signed articles in the *Canberra Times*. The letters to the editor section in this newspaper is an especially useful index. The *Canberra Times* has a stated policy of encouraging debate on public issues and as a consequence prints a large fraction of letters received²⁸, almost certainly a higher fraction than any other major newspaper. It also has very high editorial standards in normally not altering or shortening letters without the writer's consent. In Table 2 are

listed by contributor the numbers of pro-nuclear contributions to the *Canberra Times* over the three year period after the release of the Ranger First Report²⁹. The dominance of the pro-nuclear case by a relatively few contributors in the pages of the *Canberra Times* would be even more marked if column space were tallied³⁰. Table 2 illustrates the way in which a fairly small group of individuals has dominated on a national scale the pro-nuclear side of the public debate on uranium mining and nuclear power in Australia. In contrast, the anti-nuclear side has involved many more people and has had more local participation.

Table 2. Number of pro- and anti-nuclear articles and letters to the editor in the *Canberra Times* for the three year period beginning 28 October 1976, listed by contributor (excluding articles by journalists).

<i>Pro-nuclear</i>	<i>Letters</i>	<i>Articles</i>
Sir Ernest Titterton	8	8
John C. Grover*	9	
Sir Philip Baxter*	4	
M. A. Crawford	4	
Tim A. Hooke*	4	
A. Bicevskis*	3	
A. Petrosyants*		2
Leslie G. Kemany*	1	1
R. Kratochvil	2	
3 contributors, each	3	1
17 contributors, each	1	
<i>totals</i>	52	14
* <i>not resident in Canberra</i>		
<i>Anti-nuclear</i>		
Brian Martin	10	5
Mark Diesendorf	9	1
6 contributors, each	3	
1 contributor	1	1
10 contributors, each	2	
4 contributors, each		1
53 contributors, each	1	
<i>totals</i>	111	11

All anti-nuclear contributors with three or more letters, and 9 of 11 with two contributions, are resident in Canberra.

Several further comments about Table 1 and its individuals are in order. First, Sir Ernest and Sir Philip have been by almost any measure the most vocal and long-standing advocates of nuclear power. The written output of either of them on this topic approximates in a rough quantitative sense that of all the other public advocates of nuclear power combined.

Second, it is noteworthy that those listed in Table 1 come from a fairly narrow range of occupations and disciplines: there is a strong concentration in nuclear science and engineering and in the mining industry. This is reflective of a more general polarisation on the nuclear issue by occupation and discipline. It is common knowledge that attitudes on issues of all sorts have a strong tendency to follow disciplinary and occupational lines³¹. This can result from self selection in gaining entrance to the discipline or occupation, educational, professional and organisational influences, and vested interests in a way of thinking and in a career. If you ask an economist for a solution to a problem, it most likely will be an economic solution³². If you ask a nuclear engineer for the solution to energy problems, more likely than not the solution proposed will include a liberal amount of nuclear power³³.

The strong representation in Table 1 from mining companies and the Australian Atomic Energy Commission thus follows a predictable pattern. Advocates of uranium mining and nuclear power are especially likely to include those who have a direct financial interest in uranium mining and those whose careers stand to benefit directly, or be justified after the fact, by expansion of nuclear research in Australia. A similar pattern has been noted among U.S. nuclear advocates³⁴. This tendency is also illustrated in a list of pro-uranium and pro-nuclear contacts in the Sydney region circulated to the media in January 1979 by a publicist working for the uranium mining industry, summarised in Table 3. This list suggests that those people who are willing to be contacts for the pro-nuclear case almost uniformly fall into one of two categories: (1) individuals working for or directly linked with uranium mining companies, and (2) nuclear scientists and engineers.

It may be asked, are the pro-nuclear views of Sir Ernest and of Sir Philip similar to those expressed by the other advocates in Table 1, or are they more moderate or more extreme? Generally my impression is that the expressed views of Sir Ernest and of Sir Philip are similar to those of other Australian public advocates of nuclear power. The views of Sir Ernest and of Sir Philip are different in being more fully elaborated, more oriented towards technical aspects of the nuclear issue, and in maintaining a particular stance towards the proliferation of nuclear weapons.

Table 3. Pro-uranium and pro-nuclear persons on call in the Sydney area listed by John Grover, January 1979³⁵.

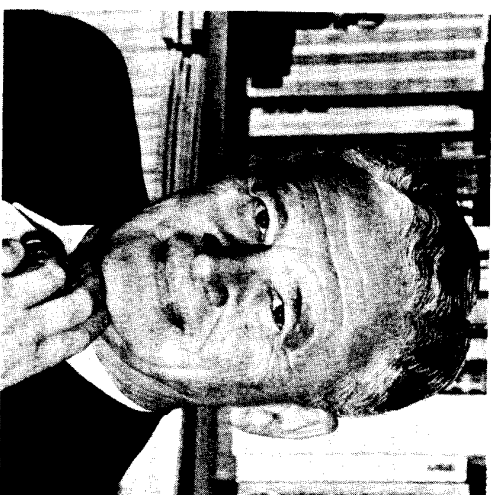
- Sir Philip Baxter*, retired, formerly Chairman of the Australian Atomic Energy Commission.
- Dr G. M. Watson*, retired, formerly Chief of the Environmental and Public Health Division, Australian Atomic Energy Commission.
- Mr Leslie Kemery*, Senior Lecturer in Nuclear Engineering, University of New South Wales.
- Mr Les Nicholls*, Manager of Operations, Ranger Uranium Mines Ltd.
- Mr Tim Hooke*, Exploration Development Officer, Geopeko Ltd.
- Mr Geoff Sherrington*, Geochemist, Geopeko Ltd.
- Dr Paul Mallop*, Chief Metallurgist and Manager-elect, Narbalek uranium mine.
- Mrs Charlotte A. Lawler*, housewife and wife of Mr J. W. Lawler, Managing Director, Queensland Mines Ltd.
- Mr John Grover*, Manager, Special Projects, Peko-Wallsend Ltd.



Some individuals in Table 1 express more moderate pro-nuclear views than Sir Ernest and Sir Philip. Butler, Raymond and Watson-Munro, who favour nuclear power, also have reservations about moving to fast reactors, and are somewhat sympathetic to solar energy³⁶. Ringwood, also a relatively cautious supporter of nuclear power, seems primarily concerned to promote his method for disposing of high level radioactive wastes, first proposed in 1978³⁷. Ringwood has also strongly criticised currently favoured waste disposal methods involving glassification and salt mine repositories³⁸. On the other hand, some individuals in Table 1 express more extreme pro-nuclear views than Sir Ernest and Sir Philip, especially Grover and Hancock³⁹. The views of most of the others listed in Table 1 seem to fall between those of Butler et al. or Ringwood on one side and those of Grover or Hancock on the other.

It may be that the views of Sir Ernest and of Sir Philip are considered by many scientists, privately, to be extreme. However, in the *public* debate there have been virtually no direct criticisms of the views of Sir Ernest and of Sir Philip by advocates of nuclear power. From the point of view of the public, Sir Ernest and Sir Philip are commonly seen as eminent authorities. For example, one story reporting a talk by Sir Ernest referred to him as "One of the world's leading nuclear physicists"⁴⁰.

In conclusion, the following analysis of the views of Sir Ernest and of Sir Philip in a very rough sense can be taken to apply to the pro-nuclear case as publicly presented in Australia⁴¹.



2. THE VIEWS OF SIR ERNEST TITTERTON

Ernest William Titterton⁴² was born in 1916 in Tamworth, England. He took the degrees of B.Sc., M.Sc., Ph.D. and Dip.Ed. from Birmingham University. From 1939 to 1943 he was a research officer with the British Admiralty, working first on radar and then on nuclear fission⁴³. In 1943 he went to Los Alamos, New Mexico as a member of the British nuclear bomb mission. There, he was a senior member of the Timing Group for the first nuclear bomb, which was exploded at Alamogordo, New Mexico in 1945. He was also adviser on instrumentation for the Bikini nuclear weapons test in 1946 and later head of the Electronics Division at Los Alamos. When in 1947 he left Los Alamos, he was the sole remaining British scientist in the US nuclear weapons programme⁴⁴.

After the four years at Los Alamos, Titterton returned to the UK to spend a little more than three years directing research at the Atomic Energy Research Establishment at Harwell. In 1950 he took the chair of nuclear physics at the Australian National University in Canberra, where he has since remained. From 1965 to 1973 he headed the Research School of Physical Sciences at ANU; he was not reappointed to the directorship following a bureaucratic struggle⁴⁵. He has sat on various advisory committees, including the National Radiation Advisory Committee (1957-

1973) and the Atomic Weapons Test Safety Committee (1955-1973), the latter as chairman from 1956. (These two committees were dissolved in 1973 and replaced by the Australian Ionising Radiation Advisory Committee, which did not include Sir Ernest⁴⁶.) He has been a member of a number of professional bodies, such as the Australian Institute of Nuclear Science and Engineering. He has also received a number of honours, including election to the elite scientific body the Australian Academy of Science. He was knighted in 1970.

Aside from his technical writings on aspects of nuclear physics and electronics, since the 1950s Sir Ernest has written numerous more general articles on nuclear power and nuclear weapons as well as many letters to newspapers. Especially noteworthy are his 1956 book *Facing the atomic future*⁴⁷ and a great increase in the writing of newspaper articles and letters since about 1976, including half-authorship of a book in 1979⁴⁸. These writings cover a wide range of topics, including for example analysis of energy sources, the hazards posed by different technologies and the role of public opinion in matters of nuclear technology.

Sir Ernest's non-technical writings can best be understood as being founded on a consistent promotion of nuclear power as a major energy source, with a primary emphasis on the relative safety of nuclear technology (including nuclear weapons tests) compared to other hazards of life. This focus is summarised in the opening sentences of a 1979 article of Sir Ernest's:

"The generation of electricity with nuclear power reactors is the cheapest, safest and cleanest means of power generation yet devised by man. It has been demonstrated to cause no more nuclear radiation problems, and far less environmental damage, than the coal-fired electricity generating industry."⁴⁹

Similar statements, though not always so direct and unqualified, can be found in numerous earlier articles.

Issues treated by Sir Ernest which do not directly support the promotion of nuclear power and its safety, such as the proliferation of nuclear weapons and the assessment of energy conservation and renewable energy sources, generally can be understood as being of secondary importance in his printed presentations. His stances on these secondary issues often can be interpreted as being structured by his central concerns. Furthermore, his views on these secondary issues sometimes appear to be adapted to changing circumstances so as to argue more effectively in favour of nuclear power and its safety.

Sir Ernest's advocacy of nuclear power is not surprising given his background and professional position, even if it is quite atypical for a nuclear scientist in its sustained and vocal character. A perception on Sir Ernest's part of a close linkage between his professional research in nuclear physics and his advocacy of nuclear power is suggested by his statement that "Fission and fusion, then, are two compelling practical reasons why we have to study low energy nuclear physics today"⁵⁰.

The main focus in the following analysis is on the ways by which Sir Ernest's various viewpoints are moulded into an internally self-consistent whole centred around his advocacy of nuclear technology. The presentation will treat successively several major themes in Sir Ernest's writings, under the broad headings of nuclear power, nuclear weapons and the nuclear debate.

2.1 Nuclear power

"The production of electricity from nuclear power is the cheapest, safest and cleanest means of power production yet devised by man" — E. W. Titterton, 1979

Sir Ernest's arguments about nuclear power fall into two principal categories, the need for nuclear power and the safety of nuclear power, which will be treated here in turn.

His case for the need for nuclear power rests on a clearly recognisable set of arguments. These were first set forth in *Facing the atomic future* in 1956 and in their essentials have not changed since⁵¹.

According to Sir Ernest, the world's population, presently about four thousand million, will continue increasing until it reaches a level of twelve to fifteen thousand million, a number which "represents the people likely to be competing for the energy resources of our planet in due course"⁵². If each of these people uses as much power as the average US citizen in the year 2000, a figure may be obtained for the rate of world energy use. This figure can be compared with known and estimated energy reserves of oil, gas and coal, with the conclusion that fossil fuels would not supply such an increased world energy usage for more than a few decades. Sir Ernest says the solution to this 'energy crisis' is nuclear fission power, including large-scale electricity generation using fast reactors, which can supply the potential world energy usage until fusion power is available to take over.

Sir Ernest claims that energy conservation, including such measures as

cutting out petrol-guzzling motor cars and providing better public transport “can only extend the lifetime [of fossil energy reserves] marginally in the face of population growth and population demand for energy”⁵³. As far as renewable energy sources are concerned, Sir Ernest claims that large-scale economic generation of electricity from the sun is a long way off at best, and that solar energy may be useful only as a supplement through solar hot water and refrigeration systems⁵⁴. Even these applications are dubious, says Sir Ernest, since solar heaters are very expensive, “cannot supply hot water during cloudy days or the winter” and due to dust accumulating on the collector’s glass surface, “the efficiency drops to near zero in a comparatively short time”⁵⁵. He also argues that other renewable energy sources have similar limitations⁵⁶.

Although one may quibble with the figures⁵⁷ used in Sir Ernest’s case for nuclear power, more revealing are the assumptions underlying it. First is Sir Ernest’s assumption that increasing living standards must be accompanied by an increasing rate of per capita energy use⁵⁸. The link between energy and gross national product has been increasingly questioned in recent years⁵⁹, but Sir Ernest only rarely⁶⁰ mentions that he has made an assumption on this matter and never mentions that this assumption is debatable. Associated with his assumption about the link between living standards and energy use is his lack of any treatment of what energy is used for. If mention were made of planned obsolescence or military production, for example, the rationale for ever increasing energy use might seem more questionable⁶¹.

Closely related to Sir Ernest’s assumption about a link between energy and living standards is an implication that peoples of the poor countries will be benefited by western-style economic and energy development. While most of the population growth referred to by Sir Ernest has been in the poor countries, most of the growth in energy use has been in the rich countries. Sir Ernest does not demonstrate, but rather assumes, that nuclear power can make a major contribution to the needs of the poor. A counter-argument is that the inadequate electricity grids and lack of money to buy electrical appliances in the poor countries means that the most urgent priorities are wood for cooking and liquid fuel for agriculture. Sir Ernest does not address this argument.

A second assumption contained in Sir Ernest’s case for the need for nuclear power is reflected in his complete avoidance of the soft energy path argument as presented by Lovins and others. The soft energy path centres around conservation and renewable energy technologies, with moderate and

then declining use of fossil fuels, and emphasises features such as flexibility and low environmental impact⁶². Sir Ernest assumes rather than demonstrates that large-scale generation of electricity by nuclear power is required, since he at no time seriously treats the soft path arguments nor even really mentions that they exist, in spite of the wide circulation of these arguments in Australia especially since 1976. It is particularly noteworthy that Sir Ernest never puts figures on the potential savings from energy conservation measures such as better insulation in buildings or the potential contribution of solar heating, in light of the many studies which have shown that such components of an energy strategy could save or contribute much greater quantities of energy than presently provided worldwide by nuclear power⁶³.

Perhaps associated with his denigration of alternatives to nuclear power, Sir Ernest seems to have an exaggerated idea of the size of the nuclear industry. He says for example that “Already it is the biggest industry in the world”⁶⁴, when in reality it is dwarfed by the oil and coal industries, among others.

Another assumption in Sir Ernest’s case for the need for nuclear power seems to be that alternatives to nuclear power must provide electricity. He says for example that solar energy “has never been harnessed to produce large quantities of electricity — solar-power stations simply do not exist”⁶⁵, while not treating as significant solar energy’s potential for producing heat. He does not mention that only perhaps 10% of energy at the point of use is required in the form of electricity.

Finally, Sir Ernest’s arguments about the poor economics of flat-plate, glass-covered solar hot water heaters ignore the many factors raised by supporters of renewable energy technologies: the need for economic evaluation over the full lifetime of the energy technology, likely economies of mass production, subsidies of low interest loans to large scale energy production, and environmental costs. The level of Sir Ernest’s analysis is illustrated by his comments about the problem of dust on solar collector surfaces which do not include mention of the simple measure of wiping it off when necessary every several months⁶⁶.

The assumptions underlying Sir Ernest’s case for nuclear power serve several functions. First, they reduce the necessity to directly face counter-arguments. This is especially important as regards the soft energy path argument, over which Lovins has fairly clearly come out on top in open debate with many advocates of nuclear power⁶⁷. Second, they allow the debate to remain, so far as Sir Ernest is concerned, on the level of the need for and safety of nuclear power. These particular issues are more closely



associated — at least in terms of public perception — with Sir Ernest's professional position and technical expertise than are the wider issues of energy strategy as argued by opponents of nuclear power. Third, the assumptions underlying Sir Ernest's case apparently justify him in dismissing the opponents' arguments and instead attacking their motives, as will be discussed in section 2.3.

An outgrowth of Sir Ernest's argument about the need for nuclear power, it would seem, is his claim that Australia has a moral obligation to supply uranium to other countries less well endowed with energy. He has made this point in a good fraction of his writings since 1976: "it is obvious that we should sell the excess [of uranium over Australia's needs] commercially to those nations who need fission power to help them maintain and improve living standards of their people. If we do not, we shall be considered selfish and arrogant"⁶⁸. However, a conclusion about Australia's moral duty to supply uranium depends on a particular conclusion about the benefits and costs of nuclear power in the widest sense, and does not constitute an independent argument. Sir Ernest has highlighted his conclusion about the moral duty of Australia to supply uranium in a way which appears to support his advocacy of nuclear power, and in a period when possible uranium export is a major issue in Australia. But to my knowledge he has never mentioned a moral duty for Australia to export coal or food, to lobby oil producers for special prices for poor countries or to make available Australia's land mass to refugees or eager emigrants from poor countries. This selective use of the moral obligation issue is readily understandable assuming the primacy of advocacy of nuclear power in Sir Ernest's views.

As well as claiming that nuclear power is the only solution to the 'energy crisis', Sir Ernest has stated, at least in the 1970s⁶⁹, that nuclear power is extremely safe and that its hazards are much smaller than others routinely encountered in daily life. The main hazards of nuclear power discussed by Sir Ernest are reactor accidents, radiation releases from the

normal operation of the nuclear fuel cycle and radioactive waste disposal. Of reactor accidents Sir Ernest has stated, for example, "In fact, in three thousand years of reactor time in power stations there has never been a single accident"⁷⁰ and "After 2200 years of power reactor operation ... there has not been a single death or injury to the public at large"⁷¹.

"there have been no injuries and no deaths among the public as a result of power station operations" — E. W. Titterton, 1979

Of radiation releases in the nuclear fuel cycle, Sir Ernest says that "it is certainly easy to arrange the entire system — through from mining the radioactive ores, processing them, 'burning' them in a nuclear power station, and disposing of the waste products — to be quite safe"⁷². Sir Ernest emphasises that the radioactive emissions from the nuclear fuel cycle are insignificant by comparing them with other hazards, such as from the increased cosmic radiation exposure from flying in airplanes or living at a higher altitude. He also compares, for example, the liquid radioactivity levels of typical nuclear power plant waste discharge with those of domestic tap water, whisky and salad oil, and compares the health hazards of nuclear power with those arising from pollution from burning fossil fuels, from motor car accidents and from falls, fire, electrocution and lightning⁷³. In particular he claims that nuclear power causes many fewer fatalities than the production of an equal amount of electricity by burning coal.

As to the problem of radioactive waste disposal, Sir Ernest says that present storage above ground in stainless steel tanks is "completely safe". He says that when this method becomes too cumbersome, "one of the many other suitable methods" will be chosen. Of these "many other suitable methods", most often mentioned by Sir Ernest are incorporation of the waste into glass or ceramic with retrievable storage in concrete vaults or geologic formations, and firing the waste into outer space by rocket⁷⁴.

There are a number of points which can be made about these arguments. When Sir Ernest said of nuclear power reactors that "there has never been a single accident" he clearly meant major meltdown accidents only. He has avoided mentioning the numerous lesser accidents and incidents⁷⁵ which suggest, at least to critics, that nuclear power reactors are not as safe as sometimes claimed. He does refer to the 1979 accident at Three Mile Island in the US as an 'accident', but only to argue that this case demonstrates the safety of nuclear power systems⁷⁶. Also, the figures of

thousands of years of reactor operation given by Sir Ernest gave an exaggerated idea of the amount of experience with large commercial power reactors⁷⁷.

Sir Ernest's claim that "there has not been a single death or injury to the public at large"⁷⁸ due to the operation of nuclear power plants is as yet unverifiable. Although the impact of radiation released routinely and during accidents may be causing or contributing to a large number of deaths and illnesses due to cancers and genetic defects, any likely expected increase in current rates of cancer and genetic disease would be statistically undetectable due to inadequate medical data. Although this point has often been made in replies to Sir Ernest and others⁷⁹, he has never mentioned nor acknowledged it. (He does however seem to accept statistical arguments about the effect of fossil fuel effluents in increasing mortality rates⁸⁰.) Nor does he mention that there has been little attempt to make and compile records of exposures and illnesses so that the health impact of radiation from the nuclear fuel cycle can be assessed.

In making his comparisons of hazards, Sir Ernest uses several techniques which tend to show nuclear power in a favourable light. First, normally he lists only the routine emissions from nuclear power plants in comparing their resulting radiation effects with other sources of radiation and with other hazards such as motor cars. But the major concerns over radiation releases are of course over nonroutine emissions, due to major accidents, earthquakes, war or diversion by criminals or terrorists, sources of hazards which Sir Ernest does not include in his listed comparisons.

Second, Sir Ernest mainly refers to the radiation hazards of nuclear power plants and seldom refers to hazards from uranium mining, uranium tailings or reprocessing plants, for example. Yet all parts of the nuclear fuel cycle are logically part of the hazard created by using nuclear power. Third, Sir Ernest refers primarily to the hazard to the public and so avoids mentioning documented hazards to workers in the nuclear industry⁸¹.

(However, he often mentions the hazard to coal miners when referring to the hazards from coal-fired electricity generation.)

Fourth, Sir Ernest rarely if ever considers the unique characteristics of nuclear hazards. The enormous scale of devastation possible from a nuclear meltdown accident or from a military strike on a reprocessing plant is considered important by nuclear critics. Also of concern is the long time scale of potential hazards created by many radioactive substances, which raises moral issues through the necessity for comparison of benefits and costs across generations⁸². Sir Ernest almost never treats such issues.

Fifth, Sir Ernest seems to accept without question the hazards to which he compares those of nuclear power, such as driving cars, smoking or mining coal. Many environmentalists have lobbied for public transport and cycleways to reduce road accidents, and against cigarette smoking because of its hazard to health. There is also great scope for reducing deaths in coal mining⁸³, and it may well be that measures to achieve this have not been taken because of the strong pressures to cut costs in this industry. But Sir Ernest only cites hazards such as driving cars, smoking and mining coal in the context of showing nuclear power in a good light.

Sixth, some of the comparisons used by Sir Ernest are with coal-fired electricity production; but he does not use other equally appropriate comparisons, such as with energy conservation, which would show nuclear power in a much poorer light. Other comparisons used by Sir Ernest are with hazards which have little to do with nuclear power, such as cigarette smoking or being overweight; but he does not use other equally inappropriate comparisons, such as with painting pictures or playing poker, which again would show nuclear power in a much poorer light.

Seventh, Sir Ernest seldom directly addresses the points raised by those who are concerned about the hazards of nuclear power. Instead, he reiterates his own case time and time again. For example, one of the few comprehensive comparisons of the health hazards from coal and nuclear power⁸⁴ found, within the very large range of uncertainty involved, that neither could definitely be said to be safer. To my knowledge, this Australian study has never been mentioned by Sir Ernest. Instead, Sir Ernest uses extensively and without question examples and figures produced by the nuclear industry and its supporters, almost never mentioning any possible shortcomings or existing critiques (see Appendix 2). For example, he presents and describes without qualification the work of Inhaber⁸⁵ claiming that solar technologies are more dangerous than nuclear. This work has been discredited⁸⁶.

It is also worth noting that Sir Ernest's case for nuclear power rests on the widespread adoption of fast reactors⁸⁷. At present there are no commercial fast reactors and therefore no suitable accident experience. Many people see the environmental hazards posed by fast reactors as far greater than those of the present generation of thermal reactors⁸⁸ and are especially concerned about the social and political implications of the 'plutonium economy'⁸⁹. Sir Ernest on the other hand says that fast reactor systems have been proved: "They have been shown to be safe; capable of generating electricity even more cheaply than the thermal nuclear stations;

to have less impact on the environment than wind power, solar power or wave power” and to generate more plutonium fuel than they consume.⁹⁰ Without any commercial operating experience with fast reactors, these claims are most dubious.⁹¹

Finally, Sir Ernest exclusively uses comparisons of hazards and avoids a joint consideration of benefits and costs. He thus avoids the question of how the same benefits might be achieved with lower costs, for example through conservation. Also, an important point, he does not discuss who gets the benefits and who takes the risks.⁹² In the case of voluntary risks, such as those taken in skiing, those who benefit take most of the risks. In the case of many involuntary risks, such as pollution from power plants or the destruction of forest ecosystems, those who benefit may be quite different from those who suffer the consequences, which may include future generations. This question is especially acute in poor countries. It has been argued that nuclear electricity in the poor countries will mainly benefit industry run by local elites or foreign corporations, and that the costs, such as the opportunity cost of utilisation of scarce capital and skilled labour, are borne by the populace as a whole with therefore special hardship on the poor.⁹³ These sorts of issues are not discussed by Sir Ernest.

Thus in many ways Sir Ernest portrays nuclear power in a favourable light by use of his hazard comparisons. This suggests that the prime consequence of his use of these comparisons is not better understanding of the hazards facing humans, but the apparent justification of nuclear power.⁹⁴

2.2 Nuclear weapons

“The nuclear power project had its roots in the military production of nuclear weapons” – E. W. Titterton, 1965

In the 1960s Titterton often mentioned the links between the military and civilian aspects of nuclear technology. He noted that “the nuclear power project had its roots in the military production of nuclear weapons”⁹⁵ and that nuclear power and nuclear weapons “are inseparable.”⁹⁶ In the same period he was suggesting that Australia should consider obtaining nuclear weapons: “consideration must now be given to deciding whether Australia, too, should join the minor nuclear league. This could be effected either by acquiring from our allies or by making for ourselves a nuclear weapon stockpile sufficient for us to be able to repel any attempted invasion of Australia”⁹⁷. Consistent with this, he opposed the creation of a nuclear-

free zone in South East Asia as neither possible nor desirable⁹⁸. He expressed the view that “Nuclear bombs are a fact of life”⁹⁹ and that with appropriate policies “these weapons can benefit all mankind by ensuring that there will never be another world war”¹⁰⁰.

Given his expressed awareness in the 1960s of the close link between nuclear power and nuclear weapons, it is not surprising that Titterton often spelled out the role of nuclear power in promoting ease of access to nuclear weapons. In 1956 he said “Australia has no atomic weapons project of its own, although once power reactors have been built in Australia it will be possible to enter the weapons field should she so desire”¹⁰¹ and in 1968, “it is quite clear that major stockpiles of nuclear weapons could be obtained from nuclear-electricity producing systems unless one does something about it”¹⁰². In the light of these views and his support for serious consideration for Australia obtaining nuclear weapons, Titterton’s opposition to the Treaty for the Non-Proliferation of Nuclear Weapons (NPT) was to be expected. Indeed, in 1969 he termed the NPT “a worthless and ineffective bit of paper”¹⁰³. He said then that a small nuclear power station could produce sufficient plutonium for 50 20-kiloton nuclear bombs per year, that cheating the NPT was possible in many ways and therefore that Australia should not sign away its nuclear weapons options for 25 years in exchange for an ineffective control system¹⁰⁴.

“The Nuclear Non-proliferation Treaty is . . . a worthless and ineffective bit of paper” – E. W. Titterton, 1969

Such views about nuclear weapons can of course be seen as quite compatible with a justification of participation in the development of nuclear weapons. Sir Ernest’s claim, which makes no mention of contrary views¹⁰⁵, that the nuclear bombing of Hiroshima and Nagasaki saved lives in the war against Japan¹⁰⁶ is also relevant in this regard.

Sir Ernest next publicly mentioned proliferation of nuclear weapons in the late 1970s, in the context of the debate over nuclear power. These more recently expressed views are rather different from his earlier ones. He now claims that since it is “easy” to make nuclear weapons without nuclear power stations, namely via uranium enrichment, therefore denying access to Australian uranium would have no effect on the spread of nuclear weapons¹⁰⁷. Furthermore, he says that reactor grade plutonium is not a suitable material for making nuclear weapons, and that if power reactors “are under international safeguards”, as is usual, they could not be used

without breach of the law to produce weapons-grade plutonium"¹⁰⁸.

In these more recent statements, Sir Ernest never mentions the still existent possibility that availability of nuclear power stations and reprocessing plants and the associated training of nuclear scientists and engineers will make nuclear weapons proliferation more probable, even if it is not the only means available. Nor in recent years has he referred to loopholes in the NPT, though he has never retracted his earlier strong criticisms of it.

The contrast is clear. On the one hand, Titterton said in 1965 that for making plutonium for bombs, "The economical way to achieve a reasonable level of production would be to install a nuclear power station"¹⁰⁹. And he opposed the NPT at that stage because he thought it was "worthless and ineffective". On the other hand, in the late 1970s Sir Ernest claims that because nuclear weapons can be manufactured via uranium enrichment, the idea that nuclear power will lead to nuclear weapons proliferation "is a non-argument"¹¹⁰. Sir Ernest has presented no substantive evidence for his change in expressed viewpoints. It seems reasonable to understand his altered stance as a response to the recent public concern over nuclear weapons proliferation via nuclear power and the consequent value in denying the significance of this link in making a case for nuclear power.

Another issue treated by Sir Ernest has been the hazards of radioactive fallout. His stance on this issue has clear links with his views on nuclear weapons for Australia and also with his claims about the low level of hazard from radiation from nuclear power programmes. In a large number of technical articles from the late 1950s to the early 1970s¹¹¹, Titterton and his co-authors reported measurements of radiation levels in Australia due to atmospheric nuclear weapons testing, for example by the French in the South Pacific. In many cases they also concluded that the fallout had "no significance as a hazard to health of the Australian community"¹¹². Such a conclusion mixes a technical evaluation of the size of the radiation hazard with a judgement as to its social acceptability¹¹³. But technical experts have no special qualification to declare a risk acceptable¹¹⁴.

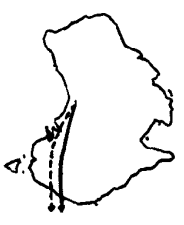
In these statements Sir Ernest wrote as chairman of the Australian Atomic Weapons Test Safety Committee, which was responsible for ensuring that Australians were not harmed by nuclear tests. It would appear that his public views on nuclear weapons for Australia at the time, and his close links with French nuclear scientists¹¹⁵, call into question his scientific neutrality in assessing the significance of the hazard of radioactive fallout. Also questionable was the suitability of his very presence on the AWTSC.

This point has been well argued and documented for both Sir Ernest and Sir Philip by Diesendorf¹¹⁶.

On 11 October 1956, a British nuclear weapon was tested at Maralinga, South Australia. The following day Titterton, then deputy chairman of the AWTSC, was quoted as having advised the Minister for Supply that "There is no danger of significant fall-out outside the immediate target area"¹¹⁷.

Two years later, a scientific report concerning fallout from this and other nuclear tests was published by the five members of the AWTSC, including Titterton. The authors of the paper emphasised throughout that the hazard from the fallout from the tests was very small. For example, they stated that "there is little danger to livestock from [radioiodine] as a result of these weapon tests"¹¹⁸. In connection with the 11 October test, they did not mention any population centres as having been subject to fallout. The closest reference to this was their description of the secondary cloud from the test as "a southerly diffusion of slowly settling material of low activity" which "was detected over South Australia, Victoria and N.S.W. during the period 12 to 16 October"¹¹⁹. The authors did mention that the largest integrated inhalation radiation dose from the test was measured at Adelaide, but did not specify accurately the direction of the secondary cloud. The tiny map in their paper showed, as well as may be determined, that the secondary cloud passed well to the north of Adelaide.

The trajectories of the main and secondary clouds (full and dashed lines, respectively) from the 11 October 1956 nuclear test at Maralinga, in the same size as presented by Titterton and his colleagues. A dot has been added in the position of Adelaide.



In contrast to this treatment by the AWTSC members was an independent study of the fallout by Dr H. R. Marston, a CSIRO scientist. Marston reported high levels of radioactive iodine-131 in the thyroids of sheep and cattle in Adelaide after the test. He stated that "the plume from the third Maralinga explosion (October 11) passed close to Adelaide and contaminated the city and surrounding country with radioactive fission products"¹²⁰ and that "extensive areas of Australia have been contaminated, and that some of the more heavy precipitations occurred on terrain situated over 1500 miles from the site of the explosions [at Monte Bello and at Maralinga], in areas more or less thickly populated"¹²¹. Overall, Marston's

paper was much clearer and more forthright about locations and possible hazards from fallout than the paper by the members of the AWTS/C. Furthermore, the published version of Marston's report was an abridged version, since much material was removed, apparently for security reasons. The very existence of Marston's full original report was only revealed publicly in 1980¹²².

Sir Ernest's stance on the lack of danger from fallout is quite in line with his arguments on the safety of nuclear power. In *Facing the atomic future*, while pointing out the serious radiological hazards posed by all-out nuclear warfare, Triterton concluded that "present weapons-test programmes are 'safe'"¹²³. In the early 1970s, Sir Ernest has subscribed to the view that fallout in Australia from French tests is "no danger to the health of anyone in Australia"¹²⁴. He has compared radiation doses from fallout with other hazards such as living above sea level, flying in aircraft and having chest x-rays¹²⁵. He has denied any significant hazard from Chinese nuclear testing¹²⁶. And he has claimed that plutonium released into the atmosphere from nuclear weapons testing has not resulted in "a single injury or death to any member of the public, as far as is known, anywhere in the world"¹²⁷. These claims may be, and indeed have been, challenged¹²⁸. In any case, many of the points made in section 2.1 about Sir Ernest's hazard comparisons apply also to his claims and comparisons concerning fallout, such as the undetectability of any likely impact on human health.

Sir Ernest's stance is that there is no significant hazard from fallout. This is compatible with and useful for his support for considering the possibility for Australia obtaining nuclear weapons. His stance also can be seen as reflecting his strong claims about the comparative lack of danger from ionising radiation from nuclear power programmes¹²⁹.

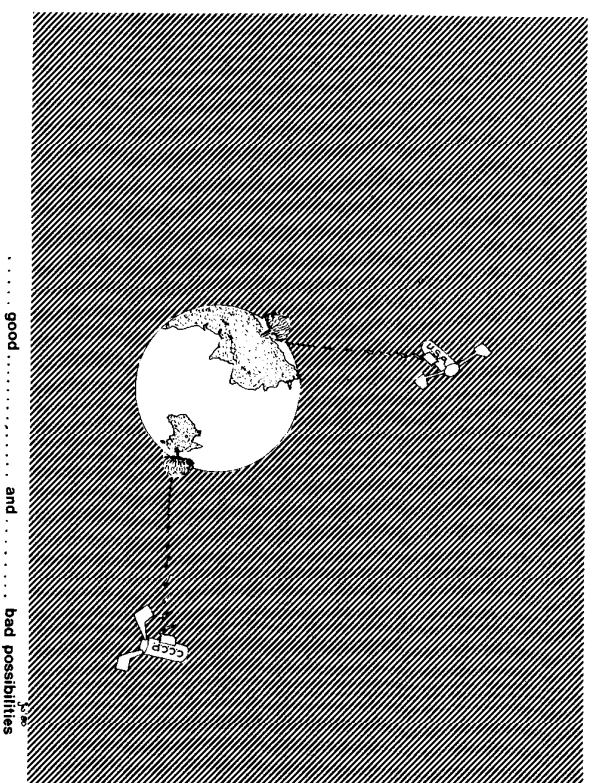
2.3 The nuclear debate

Sir Ernest's expressed views relating to the nuclear debate itself, and especially on opponents of nuclear power, can be seen as an outgrowth of his total advocacy for nuclear technology. Here his views in these areas will be placed in the context of a number of his other expressed views about nuclear power and civilisation, science, public opinion and experts.

Although Sir Ernest obviously has felt it necessary to argue strongly for nuclear power, he seems to imply he has had no doubts about its future. Since the 1950s he has talked of "nuclear power, about which it is only necessary to say that man will not have to choose the new power source —

its coming is inevitable"¹³⁰. He sees nuclear power as essential to civilisation: "It is therefore essential to the continuance of our power hungry civilisation to develop a new energy source as soon as possible and the nuclear source is the only one available on the requisite scale"¹³¹. If nuclear power is essential and inevitable, then according to Sir Ernest "we must adapt ourselves" to the changes brought in its wake¹³².

What is the role of science and technology in these developments? From Sir Ernest's point of view there is no question of trying to restrain nuclear developments if nuclear power is essential and inevitable. "It is clear that the fruits of researches in the physical and the medical sciences cannot be suppressed"¹³³, he says, and these fruits "will have good and bad possibilities"¹³⁴. Oil and coal can be used both for weapons of mass destruction and for home heating, says Sir Ernest, and likewise uranium "can be used for wreaking destruction in war or for the good of man"¹³⁵. Furthermore, he notes, "science has become so important in our lives that all decisions, including political ones, must be made with scientific considerations in mind"¹³⁶.



“[Scientists] claim no title to superior wisdom or virtue, and, outside their own special field of knowledge, they are just as likely as any other citizen to be misled” — E. W. Titterton, 1956

Who then is to ensure the proper use of scientific discoveries? Sir Ernest, at least in recent years¹³⁷, has stated that this task falls only to the appropriate scientific experts. His viewpoint here involves ideas about experts, governments and nuclear opponents.

According to Sir Ernest, experts support nuclear power: “There can be no question that the overwhelming weight of technical authority resides with the pro-nuclear power group.”¹³⁸ Because of this, he says, governments have proceeded with nuclear power programmes: “the weight of expert technical opinion ... has led to the governments of all major nations financing nuclear power stations as a safe solution to the growing energy demand.”¹³⁹ Moreover, turning the argument around, Sir Ernest frequently advocates nuclear power on the basis that it could not possibly be the case “that Governments of these nations and their expert advisors are all wrong.”¹⁴⁰ Sometimes he identifies governments with their citizens, for example referring to the large French nuclear programme and rhetorically asking, “Is there not an old saying that ‘Fifty Million Frenchmen can’t be wrong?’”¹⁴¹.

Sir Ernest’s references to experts and governments are all in the context of defending nuclear technology against criticisms. Opponents of nuclear power have argued that it is not as safe or harmless as claimed and that there are a number of preferable alternatives. In the light of the views of Sir Ernest discussed so far, it is not surprising that he should be antagonistic to them. Since he sees nuclear power as essential and inevitable, from his view nuclear opponents must be fighting against progress and the benefits of science. In the case of nuclear power, Sir Ernest says “in spite of the activities of the anti-uranium lobbies, it is obvious that the good greatly outweighs the malpractices.”¹⁴² Since from Sir Ernest’s viewpoint experts and governments are for nuclear power, the opposition must be uninformed: “It is the misleading and unfounded propaganda of the anti-nuclear lobby which has confused and worried the public.”¹⁴³ Furthermore, in challenging the weight of technical opinion which according to Sir Ernest supports nuclear power, opponents are “a small group of anti-uranium operators who miss no opportunity of spreading their propaganda.”¹⁴⁴ These views of Sir Ernest’s about nuclear experts and opponents fit nicely into a pattern reflecting and supporting his professional role and

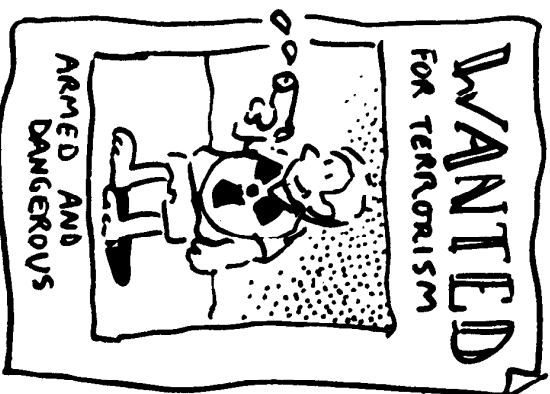
support for nuclear power. A belief in the essential need for and inevitability of nuclear power clearly can help to motivate vocal support for it and justify a career spent in nuclear science. A belief in the neutrality of science and technology allows one to avoid moral assessment of the many potential hazards from nuclear technology, especially nuclear weapons. It can also help justify the role of nuclear scientists in helping develop nuclear weapons and nuclear power. The alternative view that science and technology are not neutral¹⁴⁵ is much more threatening to many scientists since it imposes on them greater responsibility for social consequences and threatens their professional status by introducing public assessment of and involvement in scientific development.

Sir Ernest’s defence of nuclear expertise and governments has clear links with his own professional position, with the existing network of interaction between scientific elites and governments and with the increased political influence and opportunities provided to scientific elites by governments. His stated attitudes toward nuclear opponents can be seen as arising from his claim that nuclear power is essential and inevitable and that nuclear experts and governments are in the right. Dismissing nuclear opponents as only a small group of political operators also has other consequences which may be considered useful to Sir Ernest’s case. First, it avoids the necessity of acknowledging the legitimacy of questioning the nuclear experts. And second, it means that the arguments of the opponents do not need to be answered in the normal course of scientific debates. On many occasions Sir Ernest ignores the arguments of opponents and instead restates his own case.¹⁴⁶

The extent to which Sir Ernest increasingly sees the nuclear opposition as a malevolent development is illustrated by an article of 1979 in which he cites the “ludicrous position” that “the deaths, injuries and damage caused by sections of the anti-uranium movement now far exceed the possible deaths, injuries and accidental damage which could be caused by the nuclear power stations already operating and those coming into service in the world between now and the year 2000!”¹⁴⁷ The deaths referred to by Sir Ernest are those which have occurred during “pitched battles between anti-uranium protesters and the forces of law and order.”¹⁴⁸

Sir Ernest does not acknowledge that the overwhelming majority of anti-nuclear protests have been entirely peaceful¹⁴⁹. He does not acknowledge that violent tactics are abhorred and unsupported by the bulk of the worldwide opposition to nuclear power. He does not acknowledge that most of the injuries and very few deaths at anti-nuclear demonstrations have been due to the use of violent means by police such as TNT-loaded grenades

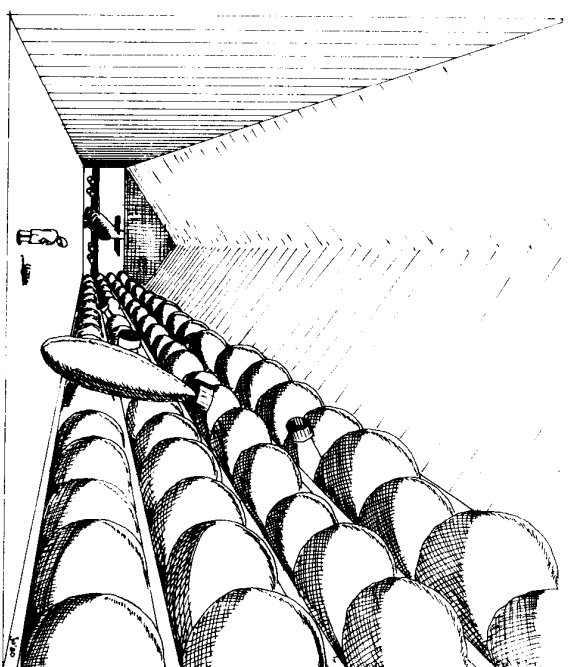
and rifles¹⁵⁰ and so generally cannot be said to be created by the protesters¹⁵¹. And he does not acknowledge that there is evidence of violence by pro-nuclear forces against nuclear opponents¹⁵². Instead, he claims that some opponents are "strident and malevolent people (often politically motivated) who have demonstrated a willingness to injure and even kill those who get in their way during their often violent demonstrations,"¹⁵³ without providing a single bit of documentation.



Of course Sir Ernest's claim comparing deaths, injuries and damage caused by the anti-uranium movement and by the nuclear power industry is itself ludicrous. The "possible deaths, injuries and accidental damage" which could be caused by nuclear power stations up to the year 2000 is at least 43,000 deaths and thousands of millions of dollars of damage from just one accident, according to official reports¹⁵⁴. This may be more or less than what will actually occur in the future, but it certainly is "possible". Sir Ernest's comparison illustrates how his total advocacy of nuclear power and dismissal of opponents seems to affect his presentation of the issues compared to that of opponents and indeed many proponents.

Opponents see nuclear power as a source of violence in society due to nuclear hazards, proliferation of nuclear weapons, potential for terrorist and criminal use, threats to civil liberties and destruction of Aboriginal culture. In contrast, Sir Ernest focusses on what he sees as violence by nuclear opponents, and completely denies any effects of nuclear technology on civil liberties¹⁵⁵. His view on the safety of nuclear power in his statement not only glosses over possible deaths from radiation already caused by nuclear power, but encompasses possible future accidents, about which it is surely presumptuous to claim knowledge.

Sir Ernest's views about public opinion may shed further light on his recent statements on nuclear experts and nuclear opponents. In *Facing the atomic future* Titterton said that "Insistence on the desirability of informed public opinion on atomic energy matters follows from the basic belief that democracy functions best when the people understand the issues."¹⁵⁶ In 1961, responding to a statement that men of science are arrogant towards the public, he commented that "As far as nuclear physicists are concerned, I cannot agree with this: in general I would say they are humble and modest and more conscious of the things they do not understand than arrogant about the things they know."¹⁵⁷



Perplexed scientist observes dead cat

Years later in 1979, Sir Ernest again refers to public opinion. He notes that while a worldwide programme to promote knowledge and understanding of nuclear power has been "effective" in convincing many people and organisations to support nuclear power, this "has not silenced the anti-nuclear lobby"¹⁵⁸. Sir Ernest appears to assume that any person with "knowledge and understanding" of nuclear power automatically will support it: "It was thought that, by making all the facts available to the public concerning the new industry and the new technology, the soundness of the decisions to develop nuclear power stations would become obvious"¹⁵⁹.

Sir Ernest's views towards opponents thus can be understood in the context of this stated belief that any informed person will support nuclear power. Given such a belief, it would have been easy to offer unqualified support for informed public opinion in the early days of nuclear power and to affirm the modesty of nuclear physicists, because there was little or no opposition to nuclear power. But by the late 1970s the belief that any informed person will support nuclear power was under challenge. Sir Ernest's dismissal of opponents as small, violent, misinformed groups which "often close their eyes and minds to the facts, however convincingly these are presented"¹⁶⁰ can be understood as a response to this challenge.

This interpretation also helps explain Sir Ernest's selective quotation of the Ranger Inquiry's comment that "we have found that many wildly exaggerated statements are made about the risks and dangers of nuclear energy production by those opposed to it"¹⁶¹. Sir Ernest followed this quote with his own reference to "the misleading and unfounded propaganda of the anti-nuclear lobby"¹⁶². However, he did not include the Ranger Inquiry's immediately following sentence: "What has surprised us more is a lack of objectivity in not a few of those in favour of it, including distinguished scientists"¹⁶³.



3. THE VIEWS OF SIR PHILIP BAXTER

John Philip Baxter¹⁶⁴ was born in 1905 in Wales. He received a B.Sc. in chemistry in 1925 and a Ph.D. in mechanical engineering in 1928, both from Birmingham University. Thereupon joining the staff of Imperial Chemical Industries, he rose to become research manager of the General Chemicals Group in 1935. He entered the nuclear field in 1940, becoming especially interested in the chemistry of uranium, and produced Britain's first uranium hexafluoride in 1941. He acted as a consultant to the British and US war-time nuclear projects, in 1944-45 spending a year at Oak Ridge, Tennessee leading a British team helping with the nuclear bomb project. On returning to Britain and ICI he continued as a consultant to the post-war British nuclear programme, in particular helping with design of the chemical separation plant at Windscale used to produce the plutonium for Britain's first nuclear bomb¹⁶⁵.

In 1950 Baxter came to Australia as professor of chemical engineering at the New South Wales University of Technology (later the University of NSW) and became Vice-Chancellor of the University in 1955. On formation of the Australian Atomic Energy Commission in 1953 he became Deputy Chairman, becoming Chairman in 1957, although this was a part-time position due to his university duties. He stepped down from being Vice-Chancellor in 1969, at that time becoming full-time Chairman of the AAEC,

from which he retired in 1972. During much of his term with the AAEC he represented Australia on the International Atomic Energy Agency, and in Australia served on the National Radiation Advisory Committee (until disbanded in 1973) among others. He is a member of quite a number of professional bodies, such as the Royal Australian Chemical Institute. He has also received a number of honours, including membership in the Australian Academy of Science and foundation fellowship in the Australian Academy of Technological Science. An active member of the Conservative Party in England for 17 years, he "forewent party politics in Australia in favour of the management of public institutions."¹⁶⁶ He was knighted in 1965.

For many years Sir Philip was the leading adviser to the government on nuclear matters, for example being the prime adviser on the Nuclear Non-Proliferation Treaty.¹⁶⁷ During his Chairmanship he was the dominant force at the AAEC.¹⁶⁸ Also, since the mid 1950s Sir Philip has published a great many articles on nuclear power and related topics, as well as writing numerous letters to newspapers and giving numerous talks to various groups. Thus his views are important both because of their impact in the public nuclear debate and because of his previously vital role in government nuclear policy making.

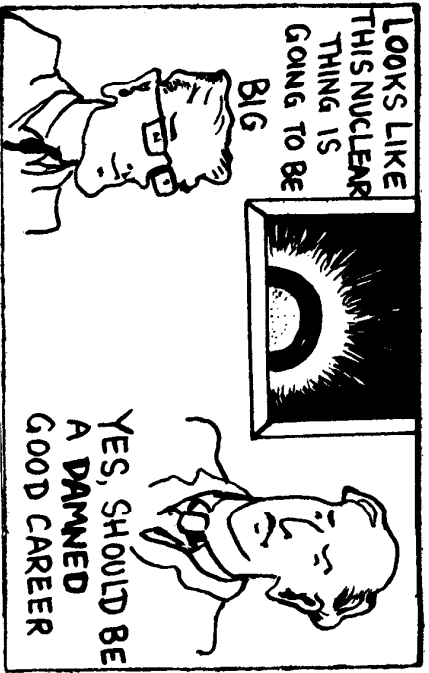
There are many topics covered in Sir Philip's output, including technical aspects of nuclear power, economic, political and military features of Australia's role in the world community, pollution, energy policy and the role of experts. Sir Philip's writings perhaps can best be understood as being based on the promotion of two interlinked goals. The first is the development of nuclear power in Australia and the rest of the world. The second is a powerful self-sufficient Australia based on a large population, development of the interior of the continent, a strong industry based on advanced science and technology and, very importantly, a strong military establishment with nuclear weapons. All this is to be supported by nuclear power: "There is no doubt, however, that the production of cheap power from uranium will be a major contribution to the problem of developing this last large land mass which is available to the white races."¹⁶⁹ This statement dates from 1955, but the basic vision has not changed significantly since then.

"Australia is the last big continent which the white man has to develop and populate. It will be a difficult task, but the full use of atomic energy should make it both easier and more certain." — J. P. Baxter, 1957



Fortress Australia

I argue here that other issues discussed by Sir Philip, such as pollution control or energy obligations to other countries, can be understood as being subordinated in his expressed viewpoint to his two primary goals. His views relating to these subordinate issues can be interpreted as being structured, and sometimes altered, to be consistent with the promotion of nuclear power and of Australian might. The centrality of the promotion of nuclear power in Sir Philip's views is quite consistent with his professional background and with his long association with the AAEC. And his advocacy of a powerful nuclear-armed Australia is not too surprising in light of his association with nuclear weapons programmes and his important role in Australian political life. The following analysis shows how other aspects of Sir Philip's viewpoint can be interpreted as being adapted to these central twin features. The presentation will consist of treatment of a number of particular issues and themes raised in Sir Philip's writings, again under the broad categories of nuclear power, nuclear weapons and the nuclear debate.



3.1 Nuclear power

To begin, it is useful to outline the pattern of development of Sir Philip's published views on nuclear power and their broad relation to current issues of social concern.

Especially in his early articles, Baxter did not so much present an argument for nuclear power as assume that it was a desirable and inevitable development. In the 1950s he was mainly concerned with where nuclear power would first be used (such as places where coal is remote or expensive), with the new industries brought into being to handle the nuclear fuel cycle, with the use of nuclear power in opening up the Australian interior, with the development of nuclear powered shipping and with the training of personnel for nuclear and other industries¹⁷⁰.

Sir Philip has publicly addressed problems associated with nuclear power usually only *after* these problems have received public discussion. Two such problems are environmental hazards of nuclear power, and nuclear power's inability to replace cheap liquid fuel. Significant treatments of the environmental and health hazards associated with nuclear power first appeared in Sir Philip's writings in about 1970, somewhat after the time environmental issues first generated widespread interest¹⁷¹. Similarly, he only began treating the problem of providing for liquid fuel in about 1978, somewhat after the issue of liquid fuel became in Australia a serious problem

for the nuclear power/coal energy strategy¹⁷². This lag in publicly treating problems facing nuclear power is understandable. It would be surprising if advocates of nuclear power were the first to promote public discussion of problems involving nuclear power.

At various times Sir Philip has made predictions about the development of nuclear power in Australia and overseas. In Table 4 some of his predictions for Australia are listed. The continued overoptimism of Sir Philip's predictions can be seen as a result of a natural tendency on the part of an advocate, as an attempt at self-fulfilling prophecy, or a bit of both.

Table 4. Some predictions made by Sir Philip Baxter about the development of nuclear power in Australia¹⁷⁹.

- 1955 prediction*¹⁷³: "The prospects for producing economic atomic power in South Australia within the next decade are therefore good."
- 1969 prediction*¹⁷⁴: 1980, 1000MW installed nuclear capacity; 1990, 12000MW; 2000, 44000MW.
- 1970 prediction*¹⁷⁵: 1980, 1000MW nuclear capacity under construction or completed; 1990, 11500MW; 2000, 36000MW.
- 1972 prediction*¹⁷⁶: "Australia would certainly begin building nuclear power stations within the next 10 years".
- 1974 prediction*¹⁷⁷: 1990, 11500MW nuclear power capacity; 1995, 22500MW; 2000, 36000MW.
- 1980 state of affairs*: no nuclear power plants built, under construction or firmly planned anywhere in Australia¹⁷⁸.

Concerning the environmental and health hazards of nuclear power, Sir Philip generally says that these are quite small and that they are being well handled by appropriate experts. Around 1970 Sir Philip was claiming that nuclear power had the advantage of "an absence of pollution problems"¹⁸⁰ or, more cautiously, that nuclear power does not cause pollution "in the sense in which most of us use that word"¹⁸¹. In discussing the release of radioactivity from nuclear reactors, he says that such releases are always within permitted limits. Furthermore, he says nuclear reactors are designed considering "every possible kind of accident resulting from the failure of any item of plant", so that accidents are either impossible or their consequences are kept completely under control¹⁸². As far as nuclear wastes are concerned, according to Sir Philip the fission products recovered from the

reprocessing of spent reactor fuel will be initially stored for a period, then converted to a stable solid form and finally stored at ground level and supervised for 1000 years¹⁸³. He claims that "Nuclear waste is a non-problem"¹⁸⁴, meaning, as he notes elsewhere, that the solution to the waste problem is known and is practicable¹⁸⁵.

"plutonium [is] one of the most poisonous substances known" — J. P. Baxter, 1954
"plutonium . . . is only 20 times as toxic as the caffeine in our coffee" — J. P. Baxter, 1979

Since Sir Ernest's similar arguments about the hazards of nuclear power have been discussed extensively in section 2.1, only a few points are made here about Sir Philip's position. First, Sir Philip, as might be expected from a strong advocate of nuclear power, downplays the hazards much more than many of the scientists who have studied the issue, including many supporters of nuclear power¹⁸⁶. Second, Sir Philip often incorporates value judgements into his technical statements, as for example when he says "development of nuclear power can be carried out, under proper supervision, preferably international, without danger to human health or to the environment"¹⁸⁷. Since there is inevitably some danger, Sir Philip obviously means here 'without unacceptable danger', in which case the statement incorporates a value judgement¹⁸⁸. Third, Sir Philip suggests that any potential hazards have been, are and will be taken care of by the appropriate experts and authorities, as for example when concerning waste disposal technology he says "The required processes have been well established on a pilot scale and no problems need be expected"¹⁸⁹. The implication in many of Sir Philip's presentations seems to be that since it is possible that hazards will be controlled, they certainly will be and there is no need for outsiders to be concerned.

In discussing the hazards due to nuclear power, Sir Philip sometimes compares them to other hazards of daily life. In one sample case he concludes that "The hazards from nuclear-reactor accidents are clearly well within the pattern which industrial man accepts as the price of the benefits which industry confers upon him"¹⁹⁰. One particular comparison of hazards often used by Sir Philip is that between the uses of coal and nuclear power to produce electricity.

Since about 1970 Sir Philip has continually proclaimed against the environmental and health costs of burning fossil fuels, especially atmospheric

pollution and the hazards of coal mining¹⁹¹. He claims that use of coal alone for electricity production, without nuclear power, "apart from killing a very large number of people would create environmental hazards which can only be described as horrific"¹⁹². But neither does Sir Philip see nuclear power alone providing electricity. He sees coal and nuclear power as complementary¹⁹³, and occasionally suggests that coal be saved for use in producing liquid fuel, gas and chemicals¹⁹⁴.

Although Sir Philip emphasised the hazards of heavy coal usage from about 1970 to 1977, since 1978 he has advocated *greater* use of coal, but now for producing liquid fuel rather than electricity. He advocates expanding Australian coal production from about 60 million tonnes per year to about 180 million tonnes per year to provide the raw material for synthesising liquid fuel¹⁹⁵. Besides the higher price of oil, a primary reason for Sir Philip's recent advocacy of coal is the present political and economic dependence imposed on Australia through importing one third of its oil¹⁹⁶. (Another reason — although Sir Philip never mentions this — is presumably the inadequacy of using nuclear power to power transport in the immediate future.) Thus while Sir Philip favourably compares nuclear power with coal in his evaluation of environmental and health effects, it would appear that the hazards of coal take second place in his concerns to maintaining secure independent sources of Australian liquid fuel.

3.2 Nuclear weapons

"We need a varied array of missiles of short and medium range, some of which should carry nuclear warheads" — Sir Philip Baxter, 1976

In the 1950s and 1960s Sir Philip advocated that Australia keep its options open in terms of planning for a nuclear weapons capability. In the 1970s he has explicitly advocated acquisition of an Australian nuclear weapons arsenal¹⁹⁷. This advocacy has obvious links with the promotion of nuclear power and of a powerful Australian military establishment. It is interesting to trace the impact of Sir Philip's nuclear weapons advocacy on three areas of his concern: the specific types of nuclear power technology which he has favoured for Australia, the proliferation of nuclear weapons and Sir Philip's vision of an impending world holocaust.

The making of choices between different types of nuclear power

technology can be based on several grounds, such as economics, safety and technical convenience. Sir Philip's advocacy of a powerful, self-sufficient, nuclear-armed Australia has apparently influenced his public advice on the appropriate selection of nuclear technology to be introduced in Australia at various times. In a 1957 discussion of nuclear power, Sir Philip noted that "should Australia follow the present world tendency and base her defence on nuclear weapons", the best way would be through a combined nuclear power/nuclear weapons project such as Calder Hall in Britain; otherwise nuclear power would have to justify itself economically.¹⁹⁸

In 1970, the Australian government was assessing tenders for a nuclear power station at Jervis Bay. Any nuclear power reactor obtained by Australia would have increased the opportunities and pressure for a nuclear weapons programme. Some reactor types would have made weapons production more easy technically than others, while reactor types which allowed for self-sufficiency would have made weapons production more easy politically.

Sir Philip at that time discussed in several articles the different types of power reactors which might be selected and their advantages and disadvantages. While acknowledging that economics was a prime factor, Sir Philip also noted some other considerations which he felt were important, in particular whether Australia would be self-sufficient in fuel for its reactors. For example, light water reactors would have required slightly enriched uranium, and hence dependence on foreign enrichment capacity for a period likely to last decades. Sir Philip noted that by having reactors which use unenriched uranium and having indigenous uranium, "the use of natural uranium gives complete freedom from imported fuel and eliminates all risks of interruption to fuel supplies upon which the life of the nation could come to depend".¹⁹⁹ Upon switching his preference to an enriched uranium reactor in late 1970, Sir Philip then suggested that a power reactor should be "a good plutonium producer", a requirement which has clear links with the potential for producing nuclear weapons.²⁰⁰

Another alternative producing nuclear independence would be the construction of Australian uranium enrichment capacity. Research work on the design, construction and testing of centrifuges for enrichment began at the AAEIC in 1965, as was made public in AAEIC annual reports in the early 1970s.²⁰¹ Sir Philip began publicly suggesting the construction of a uranium enrichment plant in Australia in the early 1970s,²⁰² although he realised the difficulties in competing with cheap US enrichment capacity built originally for military purposes.²⁰³ In the latter half of the 1970s he has strongly

advocated Australian investment in a small centrifuge enrichment plant so as to produce 25 percent enriched uranium for use in an Australian fast reactor for power production and for use in nuclear-powered ships, especially for the Australian navy. Thus Australia, according to Sir Philip, could move into fast reactors without being a pawn to any other country, could independently equip a nuclear navy, and furthermore, as he is quoted, "The possession of a centrifuge of that sort would give us, if we ever wanted it, a nuclear weapon capability" for making 50 to 75 nuclear warheads per year.²⁰⁴

In summary, a growing theme in Sir Philip's writing is that nuclear technology is needed to support an economically and militarily independent Australia with a nuclear-armed military force. This illustrates the way in which political beliefs can influence advice on technical matters.

The second area affected by Sir Philip's nuclear weapons advocacy which is looked at here is the proliferation of nuclear weapons. Concern about the proliferation of nuclear weapons capabilities and the spur provided to this proliferation by the spread of nuclear power developed in the early 1970s. As the anti-nuclear movement grew in the late 1970s, the proliferation issue became one of the strongest arguments in Australia against uranium mining and nuclear power. In this context, Sir Philip's advocacy of both nuclear power and nuclear weapons would seem to place him in a difficult position.

Similarly to Titterton, in 1957 Baxter noted "the indissoluble connection between the peaceful and military uses of fissile materials".²⁰⁵ Furthermore, over a decade later Sir Philip was quoted as follows:

"The growth of this industry and the expertise and the facilities which it will create will provide a basis from which an Australian government, at any future date feeling that nuclear weapons were essential to provide this nation's security, could move with the minimum delay to provide such means of defence."²⁰⁶

Ironically, this statement gives in precise form what many would say is a strong argument against nuclear power. Sir Philip of course does not see these points as supporting the case against nuclear power. His stance is different, and can be divided into two components. First, he considers that treaties so far developed to control nuclear proliferation, such as the Treaty for the Non-Proliferation of Nuclear Weapons (NPT), are useless. Second, he claims that world stability will be better promoted by the spread of nuclear power which will reduce conflicts engendered through energy

shortages. Indeed, according to Sir Philip proliferation of nuclear weapons in some cases may even contribute to world stability.

It is appropriate first to refer to a 1968 article about the NPT written by 'X'²⁰⁷. Whether or not the article is by Sir Philip is a matter of some dispute²⁰⁸. In any case, Sir Philip has been reported as saying he agrees with the sentiments expressed in the article²⁰⁹.

X argues that "It is pointless to look upon this Treaty as a meaningful step towards arms control or disarmament"²¹⁰ by pointing to inadequacies in the Treaty such as the difficulties of detecting hidden nuclear weapons. However, even greater objection is made by X to the powers of inspection provided by the NPT. X fears that "The tentacles of the N.P.T. could well reach into a wide range of Australian industries, State electricity generating authorities and even University and defence laboratories"²¹¹ involving "detailed examination by inspectors from Communist countries"²¹². X is wary not only of the scope of the NPT but of its duration, noting that withdrawal from the Treaty "could be a very awkward business"²¹³. It seems that X's concerns are mainly to do with national security, and even that some of X's objections to the NPT are that it might be successful in stopping proliferation of nuclear weapons rather than unsuccessful²¹⁴.

In a 1973 article, Sir Philip spells out many of the limitations of the NPT, though without the accompanying emphasis on Australian security made by X. Sir Philip apparently groups himself with those who concerning the NPT "believe that as a foundation it is so imperfect that it would be better to let it lapse and to start again"²¹⁵. As late as 1976 he wrote "While the ratification of the treaty was undoubtedly foolish, and unnecessary in that it contributed nothing to peace, it is clear that it need not inhibit Australia from developing nuclear defence facilities essential for our future security"²¹⁶. The irony here is that many of the early arguments against the NPT used by X and by Sir Philip are now used by opponents of nuclear power.

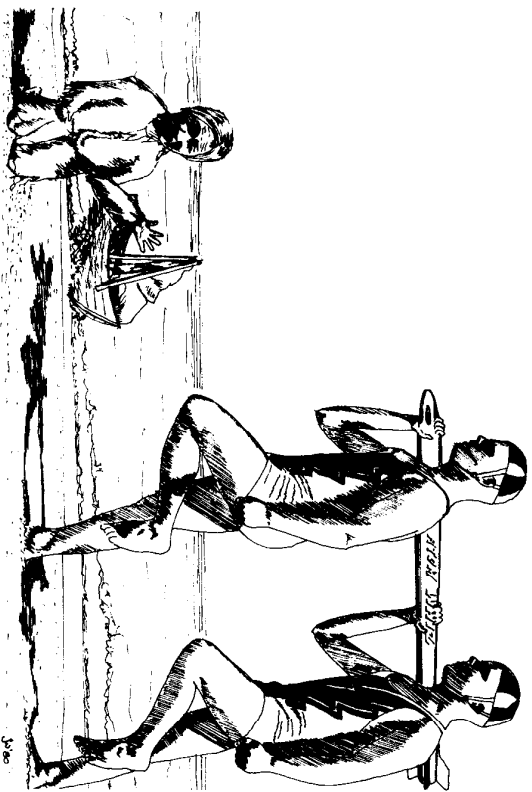
Since about 1976, especially after the release of the Ranger Inquiry First Report in October, the argument against nuclear power on the basis of its contribution to nuclear proliferation has been of major importance in the public nuclear power debate. It is only since this time that Sir Philip has pointedly addressed the role of nuclear power in proliferation. He now claims that there need be no concern about nuclear weapons being obtained as a by-product of the nuclear power industry, because producing plutonium for nuclear weapons requires running nuclear power plants in an uneconomic manner that cannot be concealed²¹⁷. Sir Philip also says that the NPT and

the IAEA safeguards and inspection system "achieves a high level of efficiency" in preventing proliferation: "Safeguards are devised to make this operation well nigh impossible"²¹⁸. The second reason nuclear power does not now contribute to proliferation, according to Sir Philip, is that it is easier to make nuclear weapons via uranium enrichment technology²¹⁹.

These claims are based on the assumption, unsubstantiated by Sir Philip, that countries will be successfully discouraged from producing nuclear weapons by means officially proscribed by the NPT but will feel no hesitation or encounter no opposition in pursuing officially non-proscribed avenues. Sir Philip has also failed to readdress his earlier point that the human and material infrastructure required to develop and maintain nuclear power technology makes it easier to move to the production of nuclear weapons if a decision to do so should be made. Instead, Sir Philip turns the nuclear power/proliferation argument on its head when he says "Holding back nuclear power programmes because of ill-founded fears that the possession of such stations by those countries which need them will promote proliferation, will by extending the period of Western energy dependence make nuclear war more rather than less likely"²²⁰. He thus claims that Australia needs nuclear weapons for its defence and also should promote nuclear power to promote peace. A full understanding of this viewpoint requires reference to Sir Philip's vision of the impending holocaust.

Sir Philip envisages that as a result of the world's growing population, shortages of food, the increase in oil prices and the continued arms race, a global disaster causing the deaths of hundreds of millions of people through nuclear war or famine or both is likely by the year 2000. Sir Philip envisages that in the ensuing global chaos, "nations will be on their own and the strong will take what they require and the weak will submit or perish"²²¹. For Australia to survive this future catastrophe, Sir Philip says that Australian conventional military forces should be bolstered, a nuclear weapons capability developed, Australian secondary industry protected and promoted and the interior of Australia opened up. By these means Australia could emerge in the forefront after a world disaster, according to Sir Philip²²².

"There may be many refugees seeking to come here [after a global disaster] . . . We should . . . look to our moat and make sure we invoke to the full those arms of science with which we can make it impregnable" — Sir Philip Baxter, 1972



However, Sir Philip says, this will also require protecting Australia from refugees fleeing the holocaust, people who might have “shattered gene systems from radiation exposure” or who “carry uncontrollable infectious disease”, and protecting Australia from invaders of the country “who would take it from us and destroy all that we stand for.”²²³ To repel invaders and refugees, Sir Philip says Australia should consider using nuclear, chemical and biological weapons²²⁴. Sir Philip first detailed these views in public shortly after he retired from the AAEC in 1972. However, he had foreshadowed them earlier²²⁵ and has been quoted as saying that these had been his views for many years²²⁶. This vision of the holocaust has clear links, which need not be spelled out here, with Sir Philip’s views on nuclear weapons, world and Australian population and Australia as a world power. Sir Philip from 1971 to 1975 implied or stated that global disaster was inevitable²²⁷. But in his 1977 article treating proliferation he insists instead that it is precisely through the rapid development of nuclear power that “the risk of a nuclear holocaust, affecting almost all life, can be made less likely”²²⁸. Sir Philip thus advocates Australian acquisition of nuclear weapons partly on the basis of protecting Australia against invaders and

refugees from a world holocaust, and advocates nuclear power partly on the basis that it will help make such a holocaust less likely. Sir Philip does not accept the widely held conviction that Australian acquisition of nuclear weapons could well increase local political and military rivalries and instability and thereby make global nuclear war more likely²²⁹. Instead, unifying his views on the desirability of nuclear power and also of nuclear weapons are his stated convictions that “I find it very hard to be unduly concerned about what is called prolifer[ati]on of nuclear weapons” and that this proliferation in some situations such as the Middle East “might even be a contribution to world stability”²³⁰. However, these views of his are not backed by documentation or detailed arguments.

Mention has been made of Sir Philip’s concern over population. He sees overpopulation as one of the greatest problems facing the world, as one of “the root causes of the environmental deterioration”²³¹. He thinks that the world population of 3500 million is 1500 million more than it can stand²³². But he desires that Australia’s population, currently about 14 million, should eventually be the size of America’s, over 200 million²³³. Sir Philip makes this double standard quite clear: “I would hope that there’s no one proposing a zero population growth for Australia although I’m a great advocator of it for all the rest of the world”²³⁴. This advocacy of greater population for Australia clearly can be seen as part of a vision of Australia as a future world power in which Australia’s interior is ‘opened up’ for agriculture and settlement with nuclear power providing the means for making available energy and fresh water.

Incidentally, one may reasonably infer that Sir Philip’s vision of a large Australian population is of one that is predominantly white. In the 1950s Sir Philip saw Australia as “the last big continent which the white man has to develop and populate”²³⁵. In the 1970s his concern over foreign threats to Australia seems to focus on Japan²³⁶ rather than the USSR. Presumably his proposals for repelling refugees in the wake of a global disaster assume that the refugees will not be whites²³⁷. Also relevant in this regard is his almost complete avoidance of the issue of Aboriginal land rights and the impact of uranium mining on Australian Aborigines²³⁸.

There is also an apparent contradiction in Sir Philip’s views about invaders. He is reported as saying that if Australia does not sell its uranium to Japan, the Japanese would have a moral argument for coming and taking it²³⁹. But Sir Philip does not use the analogous line of argument that if Australia does not sell its territory to potential invaders (and refugees), they would have a moral argument for coming and taking it. Instead, he

advocates considering repelling them with nuclear weapons. The contradiction is resolved if it is noted that his statement about Japan serves to promote nuclear power while his statements about invaders and refugees are part of his case for a powerful Australia.

3.3 The nuclear debate

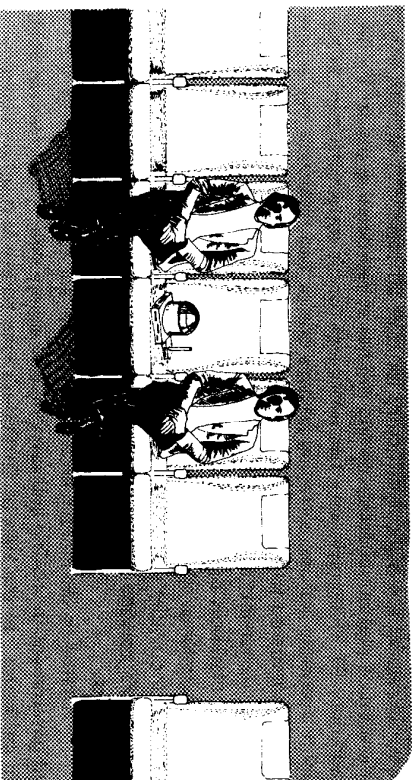
Sir Philip's published views on the role of experts in social decision-making can be interpreted as having changed according to the strength of public opposition to nuclear power. In 1972 Sir Philip noted that "As you know you can always find enough scientific experts to prove almost anything and the contrary"²⁴⁰. A year later he said "I suppose in a different political system [than democracy] it [decisions] would be settled quite simply by the technical experts making their own value judgements and they probably wouldn't be better than anybody else"²⁴¹. At the time of those statements, public opposition to nuclear power around the world was small and virtually non-existent in Australia.

**"The experts must in the end be trusted." —
J. P. Baxter, 1975**

In about 1976, however, Sir Philip began presenting a new, but soon often repeated position about experts. This position is usually stated by Sir Philip by analogy: if one is stricken with violent pain, one rushes to an expert doctor rather than consulting a meeting of people living nearby; or if one is flying in an airplane one trusts the expert pilot rather than entrusting the flying to a group of passengers. Analogously, according to Sir Philip, one should trust the experts in the issue of energy policy: "the experts see nuclear power as our way of salvation"²⁴².

In "the parable of the foolish passengers", Sir Philip uses the passengers who want to fly the airplane to represent environmentalists. In his parable, three passengers take over the flying of the plane at gunpoint and the plane crashes killing 680 people, but the director of an environmental association is sure that "the public would be delighted that no grass on the airfield had been defiled" and the three passengers escape by parachute to retire wealthy on money from unknown sources²⁴³.

The moral of Sir Philip's story is that only the experts, in particular nuclear experts, can solve the world energy crisis²⁴⁴. The story however does not address a different point: that just as an airplane pilot is not necessarily the best person to tell us whether to travel by plane, ship, car, rail or bicycle, neither are nuclear scientists and engineers necessarily the



The foolish passengers

best persons to advise on all the multi-faceted non-technical aspects of energy policy. Neither does Sir Philip present other analogies closely similar to his own, such as that we should trust the expert in manufacturing breakfast cereals to tell us what to eat for breakfast and trust the expert in tobacco horticulture to tell us whether to smoke cigarettes.

Upon analysis, there are several assumptions underlying Sir Philip's analogy which may be discerned²⁴⁵. The analogy assumes that energy policy decisions are solely technical, assumes that professional integrity alone is enough to make the experts serve the public interest, and suggests that Sir Philip is an authorised spokesperson for the relevant group of experts in Australia. Sir Philip does not mention any of the evidence and examples which cast doubt on these assumptions²⁴⁶.

It may be noted that Sir Philip made statements about the lack of superiority of decisions made by experts at a time when the role of nuclear power was unquestioned, and introduced his 'trust the expert' analogies at a time when opposition had become significant.

Consistent with Sir Philip's views about experts is the style of his presentations, in which views are stated without any suggestion that there might be a valid difference of opinion. For example, he says "The enclosed and shielded technology for processing plutonium is well established and has

been in regular use without difficulty for over 20 years'²⁴⁷, without any mention of plutonium accidents and failures at reprocessing plants²⁴⁸. In addition, Sir Philip gives very few references for his statements even in his more academic articles, averaging perhaps one or two references per article overall compared to a much higher average number of references used by scientist opponents and some other proponents of nuclear power²⁴⁹. Of course, references by themselves do not guarantee improved accuracy or better arguments. But Sir Philip's relative lack of use of them perhaps requires the reader who accepts his points to rely more than otherwise on Sir Philip's prestige rather than on detailed substantiation provided by his arguments.

Related to Sir Philip's ideas on expertise are attitudes towards the role of government in making and carrying out energy policy, and nuclear policy in particular. In the light of Sir Philip's long tenure as head of a government research organisation and his role as government advisor, it is not surprising to find that he has often come out in favour of government involvement in mining uranium, in the development of nuclear power and in the general business community. For example, concerning uranium mining in the Northern Territory, Sir Philip in 1973 said "'I do not believe the ordinary approach of multi private enterprise mining should be permitted in this area, but that it should be developed under a single authority with a single plan'²⁵⁰. And he has made harsh comments about the role of private enterprise in the UK and US nuclear programmes²⁵¹. However, Sir Philip has not to my knowledge publicly criticised the actual "multi private enterprise mining" being allowed by the Australian government in the Northern Territory, nor criticised the actual scale or expansion plans of the nuclear power programmes in the UK and US. Such criticism would be a discordant note in his general advocacy of nuclear power.

Also linked to Sir Philip's attitudes toward government may be his view that experts should be independent from the profit motive and from public pressure. So although he holds strong anti-communist views, Sir Philip finds that "it is difficult not to admire the growing Russian nuclear power program'²⁵². One might infer that Sir Philip would hold that societies should adapt to the demands of technology and technologists, rather than vice versa.

“‘open government’ . . . is a dangerous heresy” –
J. P. Baxter, 1975

The specific issue of Sir Philip's view of the appropriate relationships between nuclear expertise, the AAE, the Australian government and the public is well treated in a study by Moyal. Of Sir Philip, Moyal says that "He saw himself, and by extension the Commission, as the central and sole source of policy proposals for nuclear developments in Australia, and as the Government's fountainhead of atomic knowledge and ideas"²⁵³. Also revealing is Sir Philip's highly publicised reply to Moyal's article, in which Sir Philip says that open government, the "concept that all decisions of government should be the subject of public debate . . . is a dangerous heresy" and that "The experts must in the end be trusted"²⁵⁴. Aside from the anti-democratic nature of such a stance²⁵⁵ and his lack of any treatment of the limitations of expertise, Sir Philip's position here is open to the objection that rational authority is possibly only in open societies²⁵⁶. Since he is opposed to open government and defends the authority of experts, it may be deduced that his stance calls for some degree of authoritarianism.

Sir Philip's support of government also applies on the global scale, where he favours world government. He sees the most likely way in which this will happen as the collusion of the big nuclear powers "to rule the world and to rule it absolutely"²⁵⁷ by deciding population levels and living standards and enforcing international law. The national governments under such a world government would maintain internal population levels and living standards and enforce national law, says Sir Philip, and this might require generic planning and elimination of misfits. Sir Philip says that solving the population problem in an overcrowded world "is primarily a matter of laws and politics", although with the great assistance of science and technology²⁵⁸. It seems that in Sir Philip's vision of the world in the future, centralised control and planning is vital. While experts such as himself might not be rulers they might see themselves as important advisors to the actual rulers. Such a vision may be seen as a reflection writ large of Sir Philip's actual place in Australian politics in the 1950s and 1960s.

Closely related to Sir Philip's views about experts are his views about opponents of nuclear power. In the early 1970s Sir Philip sometimes mentioned the opponents of pollution, accusing many of them of "exaggeration, distortion and deliberate falsehood"²⁵⁹ and claiming that a lot of them (specifically US lawyers) were finding the "emotional environmental movement . . . a very lucrative business to be in"²⁶⁰.

“Much of what they [opponents of nuclear power] publish is a mixture of untruthful and hysterical statement, emotionally concocted to frighten the lay public, who find it difficult to distinguish between science fiction and reality” — J. P. Baxter, 1976

About 1976, paralleling his expression of new views on experts, Sir Philip began referring to opponents of nuclear power as “a small, well-funded, vocal minority”²⁶¹, much of whose publications are “a mixture of untruthful and hysterical statement, emotionally concocted to frighten the lay public”²⁶². At the same time he began claiming that the major beneficiaries of the anti-nuclear movement are the Soviet Union and the Middle East oil producing countries. By 1979 he was claiming that “the opposition to nuclear energy is orchestrated and financed, internationally, on an unprecedented scale, and can fairly be described as a conspiracy”²⁶³, and that this opposition is both infiltrated by communists and serving the interests of the Soviet Union²⁶⁴.

“The Australian anti-nuclear conspiracy is a political thing with links to international communism and the general motive of reducing the economic and military strength of the West” — J. P. Baxter, 1979

Several points are worth noting about Sir Philip’s attitude towards and analysis of opposition to nuclear power. First, although he often claims that these opponents make many misleading statements and falsehoods, he almost never documents any misleading statements or falsehoods. Indeed in one reply to an anti-nuclear article he notes that he has “resisted the temptation to take that article page by page and highlight the many errors and misrepresentations of fact and judgment which it contains”²⁶⁵. By resisting such temptations Sir Philip also avoids the risk of pitting his expertise in direct and open debate with that of opponents.

Second, Sir Philip is often highly derogatory of opponents of nuclear power. For example, in replying to a letter by Mark Diesendorf of the Society for Social Responsibility in Science (A.C.T.)²⁶⁶, Sir Philip begins thus: “Dr Diesendorf’s letter (October 13) is as wrong as most of the nonsense which emanates from the society of irresponsibility in science, or whatever they call it, that he represents”²⁶⁷. Remarks of a similar nature can be found in several articles and letters²⁶⁸. Such comments would be

highly unusual in a debate between scientists acknowledging each other’s competence and honesty. Sir Philip thus in effect denies acknowledgement of such status to nuclear opponents, although these opponents include nuclear scientists²⁶⁹.

Third, Sir Philip presents little or no evidence for his allegations about the funding, organisation and motivations of the anti-nuclear movement. His statements about the anti-nuclear movement being well-funded do not square with the precarious financial status of Australian anti-nuclear groups²⁷⁰. And in attributing the development of a citizens’ anti-nuclear movement in the west and its absence in communist countries to an international conspiracy in the service of the communists, Sir Philip ignores much evidence. He fails to mention the way the strength of the anti-nuclear movement cuts across traditional political boundaries, finding strength for example in Japanese fishing communities, among European farmers and among US suburbanites²⁷¹. He fails to mention the slowness and reluctance with which most of the traditional left parties have come to support or tolerate the anti-nuclear movement²⁷². He fails to mention that there have been suggestions of concern about nuclear power by some Soviet scientists²⁷³. And he fails to mention the virtual impossibility of public protest in communist countries²⁷⁴.

Furthermore, there are alternative explanations of the Soviet nuclear programme, all of which are unmentioned by Sir Philip, such as that it is partly a matter of keeping up with the west²⁷⁵. The most simple, straightforward and widely accepted explanation of the international nature of the opposition to nuclear power is that many people in many different regions are opposed to nuclear power²⁷⁶. By rejecting this explanation and instead tracing opposition to a politically sponsored international conspiracy, Sir Philip’s views become more internally self-consistent in that his abuse of opponents may seem justified in his terms. Sir Philip’s views on the “international conspiracy” against nuclear power, whatever their weaknesses, certainly fit nicely into his perspective by providing a reason why opposition has arisen, for not treating opponents as bona fide and for not responding to their arguments.

4. CONCLUSION

On the basis of the above analysis, two major conclusions may be drawn. The first is that it is possible to make sense of the pro-nuclear views of Sir Ernest and of Sir Philip by assuming they are built around basic themes or goals. Sir Ernest's views can be understood as being based around promotion of nuclear power and the defence of the safety of nuclear technology. Sir Philip's views can be understood as being based around the promotion of nuclear power and of a mighty, nuclear-armed Australia. These themes or goals can be seen as influencing their choices and uses of arguments and claims at any given time and thus influencing the evolution of their expressed views. This process is illustrated by their responses to the major areas of concern raised by opponents of nuclear power in Australia. These responses are summarised in Table 5.

Table 5. Essential character²⁷⁷ of the arguments and claims presented by Sir Ernest and by Sir Philip in the major areas of concern raised by opponents of nuclear power in Australia²⁷⁸.

<i>Area of concern</i>	<i>Sir Ernest</i>	<i>Sir Philip</i>
Environmental hazards in the nuclear fuel cycle	Hazards are small, under control, less than other routine hazards	Hazards are small, under control, less than other routine hazards
Proliferation of nuclear weapons via expansion of the nuclear power industry	Admitted in 1960s; denied in 1970s	Admitted in 1960s; denied in 1970s
Political and social threats of a nuclear society	Not mentioned ²⁷⁹	Not mentioned ²⁷⁹
Economic and employment disadvantages of nuclear power	Nuclear power is cheaper than alternatives; employment not mentioned ²⁸⁰	Nuclear power is cheaper than alternatives; employment not mentioned ²⁸⁰
Impact of uranium mining on Aboriginal culture	Not mentioned ²⁸¹	Not mentioned ²⁸¹
Nuclear power not a solution to energy problems	Energy growth is essential and requires nuclear power	Not mentioned
Advantages of the 'soft energy path'	Denial	Not mentioned

In only one area of concern, environmental hazards of the nuclear fuel cycle, do Sir Ernest and Sir Philip provide anything approaching a full and detailed argument. In the other areas they do not really come to grips with the arguments of the nuclear opponents. In these other areas Sir Ernest and Sir Philip either present poorly substantiated claims (as in the case of the economics of nuclear power), or simply deny or leave unmentioned the arguments of opponents (as in the case of the soft energy path argument). It seems that, whatever its merits, the Australian anti-nuclear case has not been answered by Sir Ernest or by Sir Philip²⁸².

The second conclusion arising from this analysis is that a large number of assumptions underlie the arguments and claims of Sir Ernest and of Sir Philip, that associated with these assumptions are social, political, economic and other values, and that these values have clear links with the professional and social positions of Sir Ernest and of Sir Philip. The assumptions and values built into their statements range from the use of hazard comparisons without discussion of which groups reap the benefits and which suffer the hazards, to the necessity of trusting the experts. They involve broad social issues such as attitudes towards refugees as well as technical matters such as the choice of a type of nuclear power technology.

The assumptions and values associated with the pro-nuclear cases of Sir Ernest and of Sir Philip have implications beyond their public advocacy of nuclear power, namely in their (former) roles as official science advisers. It is well known that advice to governments from scientists and committees of scientists may be coloured by non-technical assumptions and values²⁸³ and in particular by vested interests²⁸⁴. In the cases of Sir Ernest and of Sir Philip, Diesendorf has presented clear evidence of such an influence arising out of the existence of 'conflicting briefs'²⁸⁵. An example is the case of Sir Ernest's chairmanship of the Atomic Weapons Test Safety Committee at the same time as he publicly favoured Australian consideration of obtaining nuclear weapons and discounted the health hazards from French nuclear tests.

John Steinhart, professor of geology, geophysics and environmental studies and long time science adviser, found in an analysis of the characteristics of science advisers that:

"It is one of my principal theses that, to the extent scientific advice played any role in creating the momentum that carries us into a nuclear power based future, the scientists that provided this advice (and still do) were a very special and biased subset of the scientific community. They had these things in common: (a) they were drawn from a narrow set of specialties in the physical sciences (nuclear physics or chemistry and related fields); (b) they shared a

set of intensely moving experiences during World War II; (c) they were not among those who objected to weapons work or whose values dictated that they leave the field; (d) they were born between 1890 and 1920 (suggesting a common generational bias); (e) they had enough liking or tolerance for the quasi-political world of science advising to be extensively involved in the heady atmosphere of deliberating on crucial public issues at the highest levels of government. These men, and their self-selected successors have run the science advisory apparatus ever since.²⁸⁵

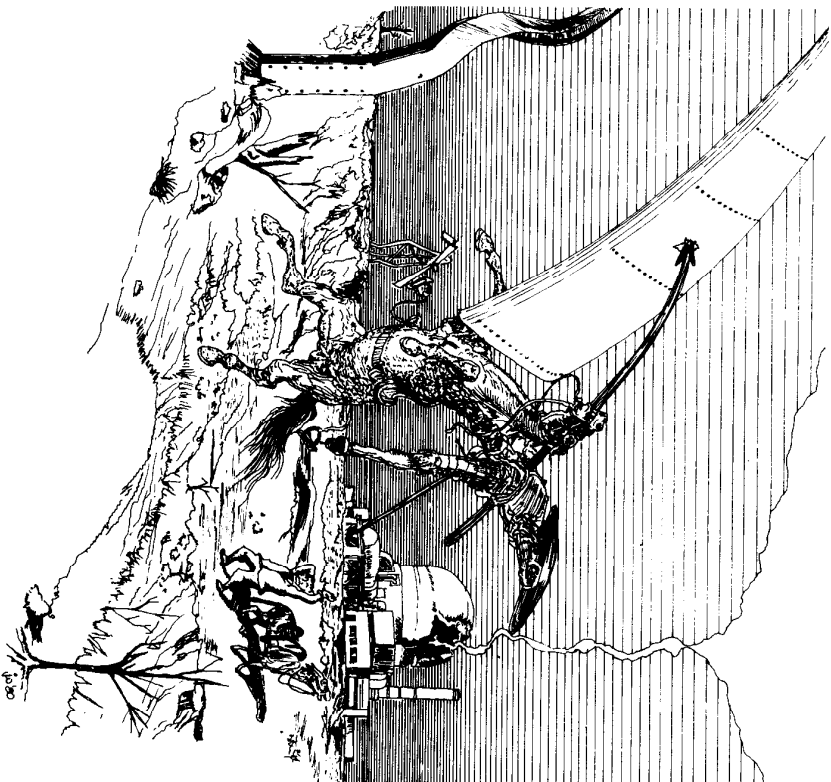
These features apply to Sir Ernest and to Sir Philip to an uncanny degree. Steinhart concludes that it is not surprising that the 'old guard' hold to nuclear power.²⁸⁷

Specific examples have been noted in the earlier analysis of the clear relation between the assumptions and values underlying the arguments and claims of Sir Ernest and of Sir Philip and their professional and social positions. At a general level, as may be noted from Table 5, they concentrate heavily on technical aspects of the nuclear issue, and mostly deny, dismiss or ignore counterarguments which are rich in social implications. The defining of problems as technical in essence enables scientists and engineers to monopolise knowledge. This helps strengthen the argumentative positions of Sir Ernest and of Sir Philip and also increases the prestige and power of their professional and social roles.

Indeed, it may be argued that the process of professionalisation can be explained as a collective attempt to translate special skills and knowledge into social and economic power.²⁸⁸ Such a process would be served well by a political position, as expressed especially by Sir Philip, that democracy stops at the doors of expertise. This new notion of political enfranchisement according to expertise²⁸⁹ clearly would legitimate the status and political influence enjoyed (at least previously) by Sir Ernest and by Sir Philip as science advisers and public spokespersons for nuclear technology, especially when issues such as nuclear power are treated as essentially technical as done by Sir Ernest and by Sir Philip.

Such status and influence is threatened by opponents of nuclear power, especially those who deny the primacy of technical factors and wish to involve the community in decision-making. This may help to explain the harsh and derogatory attitudes towards opponents of nuclear power expressed by Sir Ernest and by Sir Philip. A negative image of the opponents increases the internal consistency of the cases of Sir Ernest and of Sir Philip²⁹⁰, but at the expense of adopting unsupportable views of the opponents as irrational or as malevolent conspirators.²⁹¹

The existence of fundamental themes or goals which structure viewpoints, and the existence of assumptions and values underlying arguments and claims and of links with professional and social positions, are not unusual. But these features can be seen especially clearly in the writings of Sir Ernest and of Sir Philip, and so can help to provide a better understanding of how a particular worldview may be linked with a career in science and technology.



Appendix 1. Context of this study

An analysis of the relation of arguments to values and to social positions could be based on any of a wide range of individuals and issues. There are several reasons why the views of Sir Ernest and of Sir Philip are especially worth studying in this regard.

First, the nuclear power debate covers a wide range of issues, many of which involve social and moral questions, such as the issue of long-lived radioactive waste which raises the problem of comparison of costs and benefits between generations. Therefore views about nuclear power are likely to incorporate value assumptions to a more noticeable degree than are views about many other topics.

Second, the claims and arguments presented by Sir Ernest and by Sir Philip have been often repeated in the public debate over nuclear power. This is partly due to their own strong use of particular points, but also because as leading public spokespersons for nuclear power they have both adopted and adapted the basic approaches used by nuclear advocates around the world and have been tempted to respond to at least some of the arguments of opponents of nuclear power. So it is safe to say that many of the issues treated by Sir Ernest and by Sir Philip, and many of the assumptions underlying their arguments and claims, are not purely idiosyncratic but are central ones in the case for nuclear power. At the same time these arguments are stamped by the respective personalities of Sir Ernest and of Sir Philip.

Third, because Sir Ernest and Sir Philip are well known public figures, there is considerable information available about their careers which is helpful in suggesting possible links between their views and their social positions.

Fourth, their advocacy of nuclear power dates back to the 1950s, is extensive and is fully elaborated within their own perspectives. Hence it is possible to make a fairly comprehensive evaluation of their views both in chronological sequence and covering most of the topics in the nuclear debate. Their repeated presentations of their views give confidence that their cases for nuclear power are not based on transient information or conclusions.

Fifth, their cases are presented in newspapers, nontechnical journals, public speeches and on radio and television and hence the values underlying their views are more overt than would be the case for most technical presentations²⁹². Also, their public views are readily available, unlike for example views presented in private briefings and committee meetings.

Finally, the nuclear power issue has been the focus of major public controversy over recent years, and this has helped to highlight the values underlying the views on all sides. Because alternative viewpoints have been

presented and because their claims have been challenged, the viewpoints of Sir Ernest and of Sir Philip almost certainly have been much more forthright than would otherwise have been the case. A similar process is found in other controversies involving science and technology²⁹³.

There have been a number of previous studies relevant to this analysis. Some such studies have addressed the relationships between arguments presented and views held by scientists and their professional and social position, discipline and specialisation, mainly by treating particular cases²⁹⁴. By contrast, the present study concentrates more on the way in which the various views are organised and used to present an internally self-consistent case and less on the fairly obvious links which these views have with professional and social factors.

As to the nuclear controversy in particular, there are a number of previous studies treating both scientific aspects and professional and institutional aspects, for example of the issue of low level ionising radiation in the US²⁹⁵. Quite a number of treatments have focussed on the arguments, social bases and organisation of citizen opponents of nuclear power²⁹⁶, while a few focus on the organisations promoting it²⁹⁷.

Some of the treatments of opposition and support for nuclear power are primarily sociological, but many shade into the vast literature either opposing²⁹⁸ or promoting²⁹⁹ nuclear power. In this literature as well as the more sociological studies there is a preponderance of studies of opponents rather than proponents of nuclear power. There has also been less attention to arguments used in the debate — at least in terms of analysing them rather than attempting to refute or support them — than to the organisational and political aspects of the struggle over nuclear power. This latter emphasis is more sensible than it might seem if the actual arguments are to some extent a legitimisation of a stance adopted on the basis of economic or professional interests. In any case, there have been few detailed studies of the links between arguments, values and social positions of advocates of nuclear power. Three of the most useful studies treating the Australian situation are those by Diesendorf, by Kerr and by Moyal³⁰⁰.

It is worth spelling out why the particular definition of the current study, namely an analysis of the written views of Australian advocates of nuclear power, has been made. First, restricting the study to Australian advocates makes possible a reasonably thorough coverage of the available material. The vast bulk of material produced in defence of nuclear power throughout the world would be daunting to accumulate and analyse. Hopefully, many of the findings here will also cast light on the views expressed

by nuclear advocates in other parts of the world³⁰¹.

Second, the analysis has been restricted to written views mainly to enable full and less equivocal documentation of points made in such a controversial area. This restriction greatly reduces the scope for understanding psychological aspects which would be more approachable through speeches, interviews and the like. But written aspects of the nuclear debate arguably have had the greatest circulation and impact on the public, aside from news reports which are not directly the product of Australian advocates on either side.

Third, the analysis is restricted to public advocates of nuclear power, rather than all advocates, because relatively little information is available about the promotion of nuclear power in Australian government and industry circles. Finally, the analysis is restricted to proponents of nuclear power because the assumptions underlying their views — which have worldwide significance due to commitments to nuclear technology — have been studied less often than those of nuclear opponents.³⁰²

Appendix 2. An example of the use of evidence by Sir Ernest

In many cases Sir Ernest appears to use directly information supplied by well-recognised pro-nuclear groups, but this is not always acknowledged. A few specific examples will be given here.

Sir Ernest presents a table, "Comparison of toxic materials including reactor plutonium", in his 1979 book³⁰³. One portion of the table is as follows:

Toxin or poison injected into body	Lethal dose, milligrams	Time to death
Coral snake venom	0.005	Hours to days
Indian king cobra	0.02	Hours to days
Reactor plutonium	0.078	Over 15 Years
Diamond back rattler	0.14	Hours to days

It may be noted that the items are arranged in ascending order of lethal dose. According to Sir Ernest, "The data in this table are from S. A. Minton, 'Snakebite', *Scientific American*, Jan. 1957, and the remainder from B. L. Cohen's 'The hazards of plutonium dispersal', *Nuclear News*, 18 (8), p. 44, June 1975". However, in the quoted source by Minton³⁰⁴, a table is found with the following information:



	Length (feet)	Fang length (millimeters)	Venom yield (milligrams)	Lethal dose, man (milligrams)
North American coral snake	2-2½	2	3-5	5
Blue krait	3-4	2.5	5-10	1.5
Tiger snake	4-5	4	35-45	2
Indian cobra	4-5	4	175-250	20
Mamba	7½-9½	6	75-100	20
African puff adder	3½-4½	15	160-200	120
Russell's viper	3-4	12	150-250	50
Fer-de-lance	4½-5½	17	80-160	70
Bushmanter	7-9	25	300-500	150
Western diamondback rattlesnake	4-5	13	200-300	140

The lethal doses as listed in Sir Ernest's table for the poisonous snakes are 1000 times smaller than the values in Minton's table. Note also that Sir Ernest does not list the notable Australian species, the tiger snake.

The second of Sir Ernest's sources for his table is, according to him, "B. L. Cohen's 'The hazards of plutonium dispersal', *Nuclear News*, 18 (8), p. 44, June 1975". However, at the relevant page of *Nuclear News* is found not an article by B. L. Cohen but a news story: 'Plutonium: report assesses dispersal hazard', *Nuclear news*, 18 (8) (June 1975), pp. 44-45. This news story is about an internal report at the University of Pittsburgh by B. L. Cohen, entitled 'The hazards of plutonium dispersal'. The *Nuclear news* story does not contain any of the data in Sir Ernest's table.

Sir Ernest's table is however almost identical to one presented by the American Nuclear Society³⁰⁵ entitled "Comparison of reactor plutonium with highly toxic materials". The relevant portion of this table reads as follows:

Toxin or poison injected	Lethal dose (milligrams)	Time to death
North American coral snake venom	0.005	Hours to days
Indian King cobra	0.02	Hours to days
Reactor plutonium	0.078	Over 15 years
Diamondback rattler	0.14	Hours to days

The sources for the American Nuclear Society table are given as "B. L. Cohen, 'The Hazards of Plutonium Dispersal', *Nuclear News*, 18 (8), pp. 44-45 (June 1975) and 'The Hazards of Plutonium Dispersal', University of Pittsburgh", and "S. A. Minton, Jr., 'Snakebite', *Scientific American*, pp. 114-119 (Jan. 1957)" (p. 58).

Here are a few other selected comparisons between material in Sir Ernest's book and in the American Nuclear Society's book.

Sir Ernest

"So far there are no known deaths attributable to plutonium poisoning." (p. 79)

"Plutonium on the skin is not readily absorbed and can be washed off with no residual effects." (p. 79)

"Indeed, up to 1974, the USA had 1,155 cases where the body burdens lay between 10% and 50% of the mpl and 158 cases with much more than 50%. Among these latter were 25 men working at Los Alamos, a weapons laboratory, who had up to ten times the permissible burden. As a result of a fire in a weapons plant at Rocky Flats in 1965, another 25 men received more than the maximum permissible inhalation (lung) burden, through breathing plutonium-bearing smoke.

None of these persons has yet developed a cancer — the Los Alamos group after 32 years, the Rocky Flats group after 13 years. This strongly suggests that the fears expressed by the anti-uranium lobby relating to the toxic properties of plutonium are ill-based and scientifically unsound. They have, in fact, been rejected by reputable scientific bodies in many countries." (pp. 80-81)

American Nuclear Society

"There are no known deaths attributable to plutonium poisoning." (p. 54)

"Plutonium on the skin is not readily absorbed and can be washed off with no residual effects." (pp. 53-54)

"Up to 1974, there were 1155 cases in the U.S. where the body burdens of plutonium are between 10 and 50% of the maximum permissible level and 158 cases of burdens in excess of 50% of the maximum permissible body burden. Of these, 25 men, who worked at the Los Alamos Scientific Laboratory during World War II, are known to have plutonium body burdens between 1/10 and 10 times the "maximum permissible body burden" (and 26 times the "maximum permissible lung burden") (Ref. 10-3). Also, 25 workers received more than the maximum allowable lung burden by inhaling plutonium-bearing smoke during a fire that occurred at the Rocky Flats, Colorado weapons plant in 1965 (Ref. 10-3).

Some 30 years after receiving their plutonium exposures, none of the 25 men at Los Alamos Scientific Laboratory has developed cancer. Their health is being followed closely by periodic medical examinations. Other than the normal diseases of aging expected in men in their 50's, all the exposed men are in a good state of health (Ref. 10-3).

None of the group of 25 workers who inhaled plutonium at the Rocky Flats plant in 1965 has developed cancer, although only 10 years have passed since their exposure (Ref. 10-3)." (p. 54)

The American Nuclear Society list as their reference 10-3 a US Atomic Energy Commission report from 1974. Sir Ernest does not list a source for his information.

Sir Ernest does not mention the information that only 3 of the 25 Los Alamos workers could reasonably have inhaled *insoluble* plutonium oxide, with the total deposited being 0.0013 milligrammes. Nor does he mention the long latent period for the development of lung cancer, a minimum of 10 to 15 years³⁰⁶.

NOTES

Notes to pages 7-10

- Besides the general anti-nuclear case as presented in Australia (see section 1.2), see F. P. Robotham, "The case against", in E. W. Tritton and F. P. Robotham, *Uranium: energy source of the future?* (Melbourne: Thomas Nelson Australia/Australian Institute of International Affairs, 1979), pp. 111-194; R. B. Temple, "Nuclear power: potential for catastrophe", *Camberra Times*, 18 November 1976, p. 2; and the following contributions in the *Camberra Times*: Mark Diessendorf: letter, 11 November 1976, p. 2; letter, 30 November 1976, p. 2; letter, 28 September 1977, p. 18; letter, 12 November 1977, p. 12; letter, 28 December 1977, p. 2; letter, 10 April 1979, p. 2; Brian Martin: "Some flaws in the reasons given for selling our uranium", 13 January 1977, p. 2; "How can Australia help prevent nuclear proliferation?", 14 January 1977, p. 2; letter, 5 October 1977, p. 15; letter, 8 December 1977, p. 32; letter, 21 July 1979, p. 2; letter, 27 January 1980, p. 2. All the above, among others, address particular points raised by Sir Ernest and by Sir Phillip.
- Some useful studies of the psychology of scientists are: Anne Roe, *The making of a scientist* (New York: Dodd, Mead, 1952); Lawrence S. Kubie, "Some unsolved problems of the scientific career", *American scientist*, 41 (1953), pp. 596-613 and 42 (1954), pp. 104-112; Anne Roe, "The psychology of the scientist", *Science*, 734 (18 August 1961), pp. 456-459; David C. McClelland, "On the dynamics of creative physical scientists", in Howard E. Gruber et al. (eds.), *Contemporary approaches to creative thinking* (New York: Atherton, 1962), pp. 141-174; Bernice T. Eiduson, "Psychological aspects of career choice and development in the research scientist", in Bernice T. Eiduson and Linda Beckman (eds.), *Science as a career choice: theoretical and empirical studies* (New York: Russell Sage Foundation, 1973), pp. 1-33.
- Michael Parenti, *Democracy for the few* (New York: St. Martin's Press, 1974), p. 51: "All persons believe in their own virtue"; Electric power company official, quoted in Sheldon Novick, *The electric war: the fight over nuclear power* (San Francisco: Sierra Club Books, 1976), p. 208: "most of us have the best intentions. We are trying to do what is right for the people, for the public"; Michael Parenti, *Power and the powerless* (New York: St. Martin's Press, 1978), pp. 5, 85. But see also David Halberstam, *The best and the brightest* (New York: Random House, 1972), p. 527.
- Useful coverages of the events relating to the Australian nuclear power debate are found in Jim Falk and Neil Barrett, "The Australian setting", in Denis Hayes, Jim Falk and Neil Barrett, *Redlight for yellowcake: the case against uranium mining* (Melbourne: Friends of the Earth Australia, 1977), pp. 7-19; Wieslaw Lichacz and Stephen Myers, "Uranium mining in Australia", in Mary Elliott (ed.), *Ground for concern: Australia's uranium and human survival* (Harmondsworth: Penguin, 1977), pp. 25-63; Keith D. Suter, "The uranium debate in Australia", *World today*, 34 (June 1978), pp. 227-235; Joseph Camilleri, "Nuclear controversy in Australia: the uranium campaign", *Bulletin of the atomic scientists*, 35 (April 1979), pp. 40-44 (all the above are accounts by opponents of uranium mining); Ann Mozley Moyel, "The Australian Atomic Energy Commission: a case study in Australian science and government", *Search*, 6 (September 1975), pp. 365-384; Thomas Smith, "Forming a uranium policy: why the controversy?", *Australian quarterly*, 57 (December 1979), pp. 32-50.
- Moyel, op. cit. note 4.
- Ranger, Uranium Environmental Inquiry First Report (Canberra: Australian Government Publishing Service, 1976); Second Report (1977).
- Malcolm Fraser et al., "Uranium — Australia's decision" (Canberra: Commonwealth of Australia, 1977).
- For a critical view, see Richard Graves, "Ranger: the events behind the signing of the agreement", *Chain reaction*, 4 (2/3), 1978, pp. 46-66.
- Influential books for the anti-nuclear movement have been Hayes et al., op. cit., note 4, Ranger First Report, op. cit., note 6 and Ralph Nader and John Abbotts, *The*

- menace of atomic energy* (Melbourne: Outback Press, 1977). Other important books have been Walter C. Patterson, *Nuclear power* (Harmondsworth: Penguin, 1976). Amory Lovins, "Energy strategy: the road not taken?" (Melbourne: Friends of the Earth Australia, 1977), Elliott, op. cit. note 4 and Ranger Second Report, op. cit. note 6. The most influential magazine has been *Chain reaction*, published by Friends of the Earth Australia. There have also been a large number of leaflets, broadsheets and newsletters, some of which have achieved wide circulation, and which together have probably been as influential as books and magazines.
10. Ranger First Report, op. cit. note 6, p. 110.
 11. *Ibid.*, p. 185.
 12. Michael Flood, Robin Grove-White and Keith Suter, *Uranium, the law and you: a comment on the individual, the state and nuclear power* (Sydney: Friends of the Earth Australia/Friends of the Earth U.K./Council for the Preservation of Rural England/British National Council for Civil Liberties, 1977).
 13. Kevin O'Connor, "Uranium and civil liberties", *Dissent* (Melbourne), No. 37, August 1978, pp. 4-7, 39-40.
 14. Irvin C. Bupp and Jean-Claude Derian, *Light water: how the nuclear dream dissolved* (New York: Basic Books, 1978); Colin Sweet, "Nuclear power costs in the UK", *Energy policy*, 6 (June 1978), pp. 107-118.
 15. For figures see Ranger Second Report, op. cit. note 6, pp. 350-377.
 16. Hugh Saddler, "Fraser, Carter and the uranium market", *Intervention*, No. 9 (1977), pp. 30-42.
 17. "Undermining uranium" (Sydney: TransNational Co-operative, 1978); Richard Grossman and Gail Daneker, "Jobs and energy" (Washington, D.C.: Environmentalists for Full Employment, 1977), which has been widely circulated in Australia; numerous articles by Environmentalists for Full Employment Australia (John Andrews, 6728 Glenferrie Road, Hawthorn, Victoria 3122).
 18. The possibility of pressures from existing investment and commitment was noted in the Ranger First Report, op. cit. note 6, p. 182. The impact of a nuclear industrial and professional infrastructure has been discussed for a number of different countries: Sweden (Ingén Linnroth, Peter Steen and Thomas B. Johanson, *Energy in transition: a report on energy policy and future options* (Stockholm: Secretariat for Future Studies, 1977)), UK (Walter C. Patterson, *The fossil society* (London: Earth Resources Research Ltd, 1977)), USA (Sheidon Novick, op. cit. note 3 and Nader and Abbotts, op. cit. note 9, pp. 29-31), Canada (C. A. Hooker, R. Middleton, R. van Hulst and P. Victor, *Energy and the quality of life* (Toronto: University of Toronto Press, 1980).
 19. See Alan Roberts, "The politics of nuclear power", *Arena* (Melbourne), No. 41 (1976), pp. 22-47, which has had a wide circulation in the Australian anti-nuclear movement. See also Alan Roberts, "How can we cure the machines? Harmful technology, its reasons and remedies", in Mark Diesendorf (ed.), *Energy and people: social implications of different energy futures* (Canberra: Society for Social Responsibility in Science (A.C.T.), 1979), pp. 90-96.
 20. Ranger Second Report, op. cit. note 6.
 21. Amory B. Lovins, "Energy strategy: the road not taken?", *Foreign affairs*, 55 (October 1976), pp. 65-96, reprinted by Friends of the Earth Australia (op. cit. note 9); Amory B. Lovins, *Soft energy paths: toward a durable peace* (Harmondsworth: Penguin, 1977); Virce Taylor, "Energy: the easy path" (Cambridge, Massachusetts: Union of Concerned Scientists, 1208 Massachusetts Avenue, Cambridge, MA 02138, USA, 1979); Mark Diesendorf, "Problems of high- and low-energy futures", in Diesendorf, op. cit. note 19, pp. 27-35.
 22. Lovins, op. cit. note 21. Also see Wilson Clark, *Energy for survival: the alternative to extinction* (Garden City: Anchor Press/Doubleday, 1974); Godfrey Boyle, *Living on the sun: harnessing renewable energy for an equitable society* (London: Calder and Boyars, 1975); Peter Harper, Godfrey Boyle and the editors of

- Undercurrents* (eds.), *Radical technology* (Harmondsworth: Penguin, 1976), Denis Hayes, *Days of hope: the transition to a post-petroleum world* (New York: W. W. Norton, 1977) and Stephen Lyons (ed.), *Sun! A handbook for the solar decade* (San Francisco: Friends of the Earth, 1978).
23. The most thorough study in this vein focussing on the Australian context is Deborah White et al., *Seeds for change: creatively confronting the energy crisis* (Melbourne: Patchwork Press/Conservation Council of Victoria, 1978).
 24. Arjun Makhijani, *Energy policy for the rural Third World* (London/New York: International Institute for Environment and Development, 1976).
 25. H. W. Arndt, "The uranium debate: some economic aspects", *IPA review* (Institute of Public Affairs, Melbourne), 31 (January-March 1977), pp. 16-24.
 26. Stuart Butler, Robert Raymond and Charles Watson-Munro, *Uranium on trial* (Sydney: Horwitz, 1977).
 27. Sir Macfarlane Burnet, "Look to the sun", *Sydney Morning Herald*, 3 August 1976, p. 6 and F. M. Burnet, letter, *Age* (Melbourne), 22 August 1977, p. 8; Sir Mark Oliphant, "Dilemma of a nuclear scientist", *Age*, 26 August 1977, p. 9.
 28. Whether or not it is a conscious policy, the number of letters is kept to a manageable level by the two to three week delay usually incurred before publication, thus slowing the pace of the various running debates.
 29. I have used my personal judgement in deciding which contributions are mainly pro-nuclear, which mainly anti-nuclear and which mainly neutral. My classification is based on deciding which case is being criticised or undermined by the letter, and should not be taken to indicate that the writers of the letters are necessarily pro- or anti-nuclear, though this reservation is likely to be applicable to only a few individuals who have contributed one or two letters only in the three year period. The classification is straightforward in 95% of cases.
 30. However, the allowable length for letters and articles in the *Canberra Times* seems to depend to some extent on the prestige and formal qualifications of the contributor, and hence column space is not such a useful indicator of strength of advocacy.
 31. Several examples are given in Phillip M. Boffey, *The brain bank of America: an inquiry into the politics of science* (New York: McGraw-Hill, 1975), p. 55.
 32. Economists, at least those of neoclassical persuasion, also tend to support nuclear power. One reason is their downplaying of noneconomic factors such as environmental effects, proliferation of nuclear weapons and the psychological impact of refusing to supply uranium. Another is their belief in market forces which, for example with the assumption of infinite substitutability, will automatically provide a solution to energy problems. Therefore it is not surprising to find a traditional economist such as Arndt as a strong supporter of nuclear power.
 33. John S. Steinhart, "The impact of technical advice on the choice for nuclear power", in Lon C. Ruedisili and Morris W. Firebaugh (eds.), *Perspectives on energy: issues, ideas, and environmental dilemmas* (New York: Oxford University Press, 1975), pp. 504-513 (p. 509).
 34. Charles Schwartz, "Corporate connections of notable scientists", *Science for the people*, 7 (May 1975), pp. 30-31; more generally, see Charles Schwartz, "The corporate connection", *Bulletin of the atomic scientists*, 31 (October 1975), pp. 15-19.
 35. John Grover, "Uranium & nuclear energy reliable information sources" (15 January 1979). This document begins as follows:


"Attached is a list of informed persons in the Sydney area with a factual knowledge of uranium and nuclear issues. All of them are biased on the side of the facts but there is nothing wrong with this. Whenever you need reliable research material without delay or people able to qualify the anti-uranium anti-nuclear misinformation produced by the coterie of ex-scientists in the U.S.A. for the Australian movement, this list will be useful."

36. Butler et al., op. cit. note 26. The inadequacy of supporting thermal reactors but not fast reactors, aside from the limited energy resource in uranium without breeding, lies in ignoring institutional pressures for a fast reactor programme engendered by a large commitment to thermal reactors (see op. cit. note 18). Overlooking such political and institutional factors is perhaps to be expected from scientists such as Butler and Watson-Munro, whose conclusions about the nuclear decision in their book are mainly opinions unsupported by example or argument (see Mark Diesendorf, review of *Uranium on trial*, in *Education* (Sydney), 28 September 1977, p. 372). Butler et al.'s sympathy towards solar research may have some connection with the existence of a successful solar research programme at the Sydney University School of Physics where both Butler and Watson-Munro headed departments at the time of the publication of their book.
37. A. E. Ringwood, *Safe disposal of high level nuclear reactor wastes: a new strategy* (Canberra: Australian National University Press, 1978). See also A. E. Ringwood et al., "Immobilisation of high level nuclear reactor wastes in SYNROC", *Nature*, 278 (15 March 1979), pp. 219-223.
38. There are clear though of course not deterministic links between Ringwood's views about nuclear power and his professional interest in his waste disposal method. For example, Ringwood has said that proliferation of nuclear weapons cannot be prevented by any obvious technical measures, and that key parts of the nuclear fuel cycle, such as reprocessing, should not be opposed but rather should be internationally monitored and controlled (Anon, "Warning on nuclear 'availability'", *Advertiser* (Adelaide), 15 May 1980, p. 10). It so happens that Ringwood's method for radioactive waste disposal is based on the assumption of reprocessing spent fuel.
39. Some sample quotes from John Grover: "Factually, solar energy ... is by far the most potentially unsightly method and most dangerous per unit of energy produced"; "Thus, no arguments matter to the opponents of 'soft path'. Their soft minds are closed", from letter, *Canberra Times*, 12 April 1978, p. 18. "Only ten times less toxic than plutonium is the caffeine in your coffee!", from "Plutonium — is it the most toxic substance known?", *South Coast and Southern Tablelands Magazine*, 19 December 1977, p. 5. "Mr. McMahon and his advisors repaired our chances of having probably the cheapest reactor in the world at Jervis Bay.", "Man must mine. He must dig — or die", from "Nuclear energy here to stay", *South Coast and Southern Tablelands Magazine*, 28 November 1977, p. 2. The expressed views of Lang Hancock on nuclear power are concerned less with technical matters, but are similarly extreme.

MAN MUST
MINE HE MUST DIG
OR DIE!!

'URANIUM SERIES'

by J. C. Grover O.B.E., B.E. (Min. & Metl),
 M.Sc., F.R.G.S., F.G.S., M.I.M.M., M.Aus. I.M.M.



40. Wio Joustra, "Titterton predicts big nuclear swing", *Australian*, 27 March 1980, p. 3.
41. Collin G. Hay, "Science, environmentalism and the public", *Search*, 9 (November 1978), pp. 407-409. On a related matter, Robert Gilpin, *American scientists and nuclear weapons policy* (Princeton: Princeton University Press, 1962), pp. 7-9 considers that vocal scientists more often than not speak for politically effective scientific opinion.
42. Except as noted all biographical information is from J. S. Legge (ed.), *Who's who in Australia, 1977* (Melbourne: Herald and Weekly Times Limited, 1977), p. 1030.
43. Russell Schneider, "A fatherly defence of uranium", *Weekend Australian*, 17-18 November 1979, Magazine 2.
44. Margaret Cowing, *Independence and deterrence: Britain and atomic energy, 1945-1952 Volume 1. Policy making* (London: Macmillan, 1974), p. 113.
45. Anon, "Director's appointment in doubt", *Canberra Times*, 19 April 1973, p. 3; Anon, "Staying at ANU, says nuclear expert", *Sydney Morning Herald*, 20 April 1973, p. 2.
46. Moyal, op. cit. note 4.
47. E. W. Titterton, *Facing the atomic future* (Melbourne: F. W. Cheshire, 1956).
48. E. W. Titterton, "The case for", in E. W. Titterton and F. P. Robotham, *Uranium: energy source of the future?* (Melbourne: Thomas Nelson Australia/Australian Institute of International Affairs, 1979), pp. 1-110.
49. Sir Ernest Titterton, "Nuclear power and the anti-uranium movement", *Canberra Times*, 2 April 1979, p. 2; a closely similar quote opens Titterton, op. cit. note 48, p. 2.
50. E. W. Titterton, "Nuclear research in Australia", *Hemisphere*, 11 (January 1967), pp. 2-6 (p. 2); see also E. W. Titterton, "The future of nuclear physics in Australia", *Australian Journal of science*, 24 (21 August 1961), pp. 55-63 (p. 57).
51. Titterton, op. cit. note 47. The most complete of his recent presentations are Sir Ernest Titterton, "World energy resources: forensic and other implications", *Australian Journal of forensic sciences*, 7 (December 1974), pp. 60-70; Ernest Titterton, "World energy requirements and resources", *Australian quarterly*, 49 (June 1977), pp. 18-36; and Titterton, op. cit. note 48, pp. 4-20. See also Sir Ernest Titterton, "The world energy problem ... how Australia can help solve it", *Sydney Morning Herald*, 2 August 1976, p. 6 and Sir Ernest Titterton, "Nuclear power the only way for the future", *Age* (Melbourne), 25 November 1976, p. 9. These arguments are also a regular feature in many of Sir Ernest's talks and public lectures. See for example Anon, "Nuclear energy seen as only alternative", *Canberra Times*, 27 March 1980, p. 9.
52. Titterton, *Australian Journal of forensic sciences*, op. cit. note 51, p. 61; see also Titterton, op. cit. note 48, p. 5.
53. Titterton, *Australian Journal of forensic sciences*, op. cit. note 51, p. 64 and Titterton, *Australian quarterly*, op. cit. note 51, p. 23; see also Titterton, op. cit. note 48, p. 8.
54. Titterton, *Australian Journal of forensic sciences*, op. cit. note 51, p. 65.
55. Sir Ernest Titterton, "How feasible are the alternatives to nuclear power?", *Canberra Times*, 16 December 1976, p. 2; also in Titterton, op. cit. note 48, p. 72, where the last phrase is changed to "a comparatively few years".
56. Sir Ernest Titterton, "Bleak prospects for alternative technologies", *Canberra Times*, 17 December 1976, p. 2; see also Titterton, op. cit. note 48, chapter 7.



57. Sir Ernest's figures for population and energy use vary somewhat from one presentation to the next, though the accompanying text is often identical word for word.
- | Date | Ultimate world population | Present global rate of energy use | Estimated known fossil energy reserves | Estimated undiscovered fossil energy reserves |
|------|---------------------------|-----------------------------------|--|---|
| 1956 | | 0.0150Q/year | 40 | 400 |
| 1974 | 7x10 ⁹ | 0.120Q/year | 230 | 4520 |
| 1975 | 7x10 ⁹ | 0.280Q/year | 320 | 4520 |
| 1977 | 12.15x10 ⁹ | 0.30Q/year | 320 | 4520 |
| 1979 | 12.15x10 ⁹ | 0.30Q/year | 320 | 425.20 |
- Q is 10¹⁸ British Thermal Units. Sources: 1956 (calculated from data in Titterton, op. cit. note 47); 1974 (Titterton, *Australian journal of forensic sciences*, op. cit. note 51); 1975 (Sir Ernest Titterton, Ranger Uranium Environmental Inquiry, Transcript of Proceedings, 23 October 1975, pp. 2424-2484); 1977 (Titterton, *Australian quarterly*, op. cit. note 51); 1979 (Titterton, op. cit. note 48).
58. Titterton, op. cit. note 47, p. 63; Titterton, *Australian quarterly*, op. cit. note 51, pp. 20, 22.
59. See the comparative analyses of energy usage by Joel Darmstadter, Joy Dunkerley and Jack Alterman, *How industrial societies use energy: a comparative analysis* (Baltimore: Johns Hopkins University Press, 1977) and Lee Schipper and Allan J. Lichtenberg, "Efficient energy use and well-being: the Swedish example", *Science*, 194 (3 December 1976), pp. 1001-1013.
60. To my knowledge his only reference to this point is Titterton, op. cit. note 48, pp. 3-4.
61. Fundamental questioning of the relation of GNP to human well-being is also common. See for example Tibor Scitovsky, *The joyless economy: an inquiry into human satisfaction and consumer dissatisfaction* (New York: Oxford University Press, 1976).
62. See op. cit. notes 21 and 22.
63. *Ibid.* See also American Institute of Architects, *Energy and the built environment: a gap in current strategies and a nation of energy efficient buildings by 1990* (Washington, D. C.: AIA, 1974), cited in Lee Schipper, "Raising the productivity of energy utilization", *Annual review of energy*, 1 (1976), pp. 455-517.
64. Sir Ernest Titterton, "Environmental and other problems facing Australia", *Australian Journal of forensic sciences*, 5 (September 1972), pp. 3-9 (p. 7).
65. Titterton, op. cit. note 55; see also Titterton, op. cit. note 48, p. 69.
66. Cleaning problems have been encountered with some solar collectors due to lack of access to surfaces, for example in Israel. The solution to this problem is better design. Sir Ernest presents the problem, however, as if it were not easily surmountable.
67. "Alternative long-range energy strategies", Joint hearing before the Select Committee on Small Business and the Committee on Interior and Insular Affairs, United States Senate (Interior Committee Serial No. (94-47) (92-1371)) (Washington, D. C.: U.S. Government Printing Office, 1977), 2 volumes.
68. Sir Ernest Titterton, "Nuclear power and future energy supplies", in Harry Gelber (ed.), *International politics and world energy* (Australian and New Zealand Association for the Advancement of Science, May 1976), pp. 14-19 (p. 19).
69. In the years before nuclear power became a public issue, Titterton voiced rather more concern about the hazards created by nuclear power, in particular those posed by radioactive wastes. In 1966 Titterton considered the energy in the fission products to be "a very large quantity", cautioned that "such vast amounts of radioactivity should not be introduced into world environment except under the most carefully planned or controlled conditions" and concluded by saying that problems such as "the pollution of beaches with oil wastes ... pale into insignificance in comparison with the radioactive waste hazard — a hazard which is the inevitable adjunct of an atomic power industry." (E. W. Titterton, "Nuclear power stations and waste disposal", *Atomics*, 7 (November 1956),

- pp. 394-398 (pp. 394, 396, 398), also in Titterton, op. cit. note 47, pp. 207, 210, 213). Titterton at that time hoped that some practical use would be found for fission products, because "since they constitute a health hazard, they are an embarrassment to the project" (Titterton, op. cit. note 47, p. 180).
70. Sir Ernest Titterton, from "Discussion", in Gelber, op. cit. note 68, pp. 29-44 (p. 30).
71. Sir Ernest Titterton, "Benefits we cannot forgo", in Alan Manning (ed.), *Uranium — a fair trial* (Canberra: Australian Labor Party, 1977), pp. 19-23 (p. 21).
72. Titterton, Ranger Inquiry Transcript of Proceedings, op. cit. note 57, p. 2939.
73. The most comprehensive sets of hazard comparisons are found in Titterton, *Australian quarterly*, op. cit. note 51 and Titterton, op. cit. note 48, chapters 5 and 6.
74. Titterton, *Australian quarterly*, op. cit. note 51, pp. 34-35; see also E. W. Titterton, letter, *Canberra Times*, 23 November 1976, p. 2. Ernest Titterton, "Scare mongering on risks of nuclear waste", *Sydney Morning Herald*, 13 September 1977, p. 7 and "Disposing of atomic wastes", *Sydney Morning Herald*, 14 September 1977, p. 6, and Titterton, op. cit. note 48, pp. 87-98.
75. See for example Robert D. Pollard (ed.), *The nugget file: excerpts from the government's special file on nuclear power plant accidents and safety defects*. Obtained by the Union of Concerned Scientists under the Freedom of Information Act (Cambridge, Massachusetts: Union of Concerned Scientists, 1979).
76. Titterton, op. cit. note 48, pp. 63-67; Sir Ernest Titterton, "The lessons of Three Mile Island", *Canberra Times*, 18 April 1979, p. 15. Sir Ernest refers to the 1975 fire at Brown's Ferry in the US as an "incident" (Titterton, op. cit. note 48, pp. 62-63).
77. In 1976 or 1977, figures of thousands of years of reactor operation necessarily included reactors in nuclear submarines and tiny research reactors. According to figures as of 30 June 1976 there had been about 1000 years of operation of nuclear power plants of 30MW or over. Of these years, about 300 were with small units less than 100 MW and about 500 with medium-sized units between 100MW and 500MW. At that time there had been only about 200 years of power reactor operation with large-scale units greater than 500MW.
78. Titterton, op. cit. note 71, p. 21; see also Titterton, op. cit. note 48, p. 51. He also makes, for example, the claim that the Three Mile Island accident "did not result in a single death or injury either to workers in the plant or to any member of the public" (Titterton, op. cit. note 48, p. 64; Titterton, *Canberra Times*, op. cit. note 76).
79. Diessendorf, *Canberra Times*, 12 November 1977 and 28 December 1977, op. cit. note 1; Pamela Langley, letter, *Canberra Times*, 10 February 1978, p. 2.
80. Titterton, op. cit. note 48, p. 87.
81. Some sample accidents: Edward Gleason who died of cancer after a plutonium spillage (Patterson, op. cit. note 9, p. 236); Gerald Brown, a radiation worker with two sons suffering from the genetic disease Hurler's Syndrome (Richard Severo, "Too hot to handle", *New York Times Magazine*, 10 April 1977, pp. 15-19, 34-36; two radiation-exposed Windscale workers whose widows were awarded damages (Anon., "£30,000 award to widows of Windscale men", *Times* (London), 16 November 1977, p. 6; two Czech workers who suffocated in January 1977 following obstruction of a valve in a nuclear plant (David Satter, "Soviet plan for nuclear energy surges steadily ahead", *Canberra Times*, 14 January 1980, p. 2). The US Atomic Energy Commission in 1973 listed over 10,000 disabling accidents and 300 fatalities at its facilities over the previous 25 years (Center for Science in the Public Interest (1755 S. Street, N.W., Washington, D.C. 20009, USA), "Nuclear power: if it can go wrong, it will" (leaflet)). Many of the above accidents would be of the sort which are inevitable at any construction site or production plant. It is hard to tell how many deaths and injuries are specifically attributable to the civilian nuclear power industry, but it is clear the number is not zero. The best documented hazard is to uranium miners (see for example Arell S. Schurgin and Thomas C. Hochlocher, "Lung cancer among uranium mine workers", in D. F. Ford et al., *The nuclear fuel cycle* (Cambridge, Massachusetts: Friends of the Earth/Union of Concerned Scientists, 1974), pp. 116-148).

82. Robert E. Goodin, "Uncertainty as an excuse for cheating our children: the case of nuclear wastes," *Policy sciences*, 10 (1978), pp. 25-43; R. and V. Routley, "Nuclear energy and obligations to the future," *Inquiry*, 21 (1979), pp. 133-179.
83. Ranger First Report, op. cit. note 6, p. 113; Energy Policy Project of the Ford Foundation, *A time to choose: America's energy future* (Cambridge, Massachusetts: Ballinger, 1974), p. 183.
84. Charles Kerr, "Health effects of nuclear power," *New doctor*, No. 7 (December 1977), pp. 17-22. See also Amory B. Lovins, "Cost-risk-benefit assessments in energy policy," *George Washington Law review*, 45 (1977), pp. 911-943, also never mentioned by Sir Ernest.
85. Triterton, op. cit. note 48, pp. 76-77. The work referred to is presented in Herbert Inhaber, "Risk of energy production," AECB-119/EEV-2 (Ottawa: Atomic Energy Control Board, P.O. Box 1046, Ottawa, Canada K1P 6S9, November 1978), Herbert Inhaber, "Is solar power more dangerous than nuclear?", *New scientist*, 79 (18 May 1978), pp. 444-446, and Herbert Inhaber, "Risk from energy from conventional and nonconventional sources," *Science*, 203 (23 February 1979), pp. 718-723.
86. John P. Holdren et al., "Risk of renewable energy sources: a critique of the Inhaber report", ERG 79-3 (Berkeley: Energy and Resource Group, University of California, Berkeley, California 94720 USA, June 1979); Rein Lemberg, letter, *Science*, 204 (4 May 1979), p. 454; Richard Caputo, ibid.; John P. Holdren, Kirk R. Smith and Gregory Morris, letter, *Science*, 204 (11 May 1979), pp. 564-567; John H. Herbert, Christina Swanson and Patrick Reddy, "A risky business," *Environment*, 21 (July/August 1979), pp. 28-33.
87. Triterton, op. cit. note 47, pp. 40, 87-89, 91; Triterton, op. cit. note 48, pp. 13-14, 81-83.
88. Thomas B. Cochran, *The liquid metal fast breeder reactor: an environmental and economic critique* (Baltimore: Johns Hopkins University Press, 1974).
89. Flood et al., op. cit. note 12; Royal Commission on Environmental Pollution Sixth Report, *Nuclear power and the environment* (London: Her Majesty's Stationery Office, 1976).
90. Triterton, op. cit. note 48, pp. 85-86, 82.
91. On the safety and cost of fast reactors, see Cochran, op. cit. note 88 and Norman Dombey, "Can we afford to make the fast reactor safe?", *Nature*, 280 (26 July 1979), pp. 270-272. On the comparative environmental impact, the critiques in note 86 apply. It may also be the case that fast reactors in practice can produce only about as much plutonium as they consume (see Walter Marshall, "Plutonium breeds international unity," *New scientist*, 85 (6 March 1980), pp. 730-733).
92. R. and V. Routley, "Some ethical aspects of energy options", in Diesendorf, op. cit. note 19, pp. 113-116.
93. Walden Bailo, Peter Hayes and Lyuba Zarsky, "'500-mile island': the Philippines reactor deal," *Pacific research*, X (First quarter 1979).
94. Minimising radiation hazards through comparisons has a long history: see for example Linus Pauling, *No more war!* (New York: Dodd Mead and Company, 1958), pp. 68-69.
95. E. W. Triterton, "The nuclear power industry in 1965", *Electrical engineer*, 42 (10 June 1965), pp. 8-13 (p. 9).
96. E. W. Triterton, "Nuclear energy and bombs," *Canberra Times*, 6 August 1965, p. 2.
97. E. W. Triterton, "No gentlemen's agreement," *Bulletin*, 86 (31 October 1964), pp. 21-22 (p. 22). See also his statement, "We gain by being able to control our own plutonium production, and, as is well known, plutonium is a vital source material, not only for advanced forms of nuclear stations but also for nuclear weapons should we ever need to develop these", ABC News Commentary, 5 December 1969, quoted in Moyal, op. cit. note 4, p. 373.
98. E. W. Triterton, "An Australian bomb?", *Bulletin*, 87 (19 June 1965), pp. 20-24 (p. 23).
99. E. W. Triterton, "A worthless bit of paper", *Sydney Morning Herald*, 25 July 1969, p. 2; also Triterton, op. cit. note 98.
100. Triterton, op. cit. note 98, p. 23.
101. Triterton, op. cit. note 47, p. 138; see also pp. 337-338.
102. E. W. Triterton, "Australia's nuclear power", *Quadrant*, 12 (July-August 1968), pp. 57-63 (p. 59).
103. Triterton, op. cit. note 99; see also Anon, "Nuclear pact 'useless'", *Daily Telegraph* (Sydney), 18 July 1969, p. 7.
104. Triterton, op. cit. note 99.
105. Gar Alperovitz, *Atomic diplomacy: Hiroshima and Potsdam, the use of the atomic bomb and the American confrontation with Soviet power* (London: Sackler and Warburg, 1966); Joseph Haberer, *Politics and the community of science* (New York: Van Nostrand Reinhold Company, 1969), pp. 190-195.
106. Sir Ernest Triterton, "Comments made at the Academy's 33rd plenary scientific session on genetic engineering, February 18, 1977", *Australian journal of forensic sciences*, 9 (March 1977), pp. 105-106; Triterton, op. cit. note 48, p. 100.
107. Triterton, op. cit. note 70, p. 38; see also Ernest Triterton, letter, *Age* (Melbourne), 21 September 1976, p. 8; (Sir) Ernest Triterton, letter, *Australian Financial Review*, 13 April 1977, p. 3; Triterton, op. cit. note 71, pp. 22, 30.
108. Triterton, *Australian quarterly*, op. cit. note 51, p. 35. See also Triterton, *Canberra Times*, op. cit. note 74 and the general discussion on proliferation in Triterton, op. cit. note 48, pp. 99-105.
109. E. W. Triterton, "Australia's nuclear weapon dilemma", *Australian International News Review*, 7 December 1965, pp. 28-30 (p. 30).
110. Triterton, op. cit. note 71, p. 22.
111. See the list of publications in Atomic Weapons Tests Safety Committee, "Fallout over Australia from nuclear weapons tested by France in Polynesia from May to August 1970", Report AWTCSC No. 1 (Defence Standards Laboratories, February 1971), pp. 16-20.
112. W. J. Gibbs, J. R. Moroney, D. J. Stevens and E. W. Triterton, letter, *Nature*, 228 (17 October 1970), pp. 297-298 (p. 297).
113. William W. Lawrence, *Of acceptable risk: science and the determination of safety* (Los Altos, California: William Kaufmann, Inc., 1976), p. 8; H. D. Rathgeber, letter, *Sydney Morning Herald*, 13 August 1973, p. 6.
114. Lawrence L. McGinty and Gordon Atherly, "Acceptability versus democracy", *New scientist*, 74 (12 May 1977), pp. 323-325.
115. Anon, "Our nuclear men cement French links", *Australian*, 18 July 1972, p. 3.
116. Mark Diesendorf, "Sounding the alarms: the dilemma of the scientific expert", in Wren Green (ed.), *Focus on social responsibility in science* (Wellington: New Zealand Association of Scientists, 1979), pp. 61-83.
117. Anon, "Third atomic bomb exploded", *Advertiser* (Adelaide), 12 October 1956, p. 1.
118. W. A. S. Butement, L. J. Dwyer, L. H. Martin, D. J. Stevens and E. W. Triterton, "Radioactive fallout in Australia from Operation Buffalo", *Australian journal of science*, 21 (1958), pp. 63-78 (p. 67).
119. Ibid., p. 65.
120. H. R. Marston, "The accumulation of radioactive iodine in the thyroids of grazing animals subsequent to atomic weapon tests", *Australian journal of biological sciences*, 17 (1958), pp. 382-398 (p. 392).
121. Ibid., p. 383.
122. David English and Peter De Iorno, "Fall-out blankets a sleeping city", *Advertiser* (Adelaide), 17 April 1980, pp. 10-11; Deborah Smith and Deborah Snow, "Our atomic cover-up", *National Times*, 4-10 May 1980, p. 3.
123. Triterton, op. cit. note 47, p. 282; full discussion is on pp. 272-282.

124. Titterton, op. cit. note 64, p. 8.
125. Sir Ernest Titterton, "Radiation in man's environment", *Australian Journal of Forensic Science*, 6 (December 1973), pp. 96-100 (pp. 96-97); Sir Ernest Titterton, "The risks from fallout", *Sydney Morning Herald*, 23 June 1973, p. 6. See also Titterton, op. cit. note 47, pp. 273, 284.
126. E. W. Titterton, letter, *Canberra Times*, 24 September 1977, p. 21; (Sir) Ernest Titterton, letter, *Sydney Morning Herald*, 21 September 1977, p. 6.
127. Titterton, op. cit. note 48, p. 89.
128. For example, John W. Gofman ("Estimated production of human lung cancers by plutonium from worldwide fallout", CNR Report 1975-2 (Committee for Nuclear Responsibility, P. O. Box 2329, Dublin, California 94566, USA); for an account see Nader and Abbotts, op. cit. note 9, pp. 79-80) has calculated that plutonium already released as a result of atmospheric nuclear weapons tests may lead in the long term to one million lung cancer deaths worldwide. But because even this number of deaths would not increase the lung cancer mortality rate by a statistically significant amount, Sir Ernest's statement could not be disproved by such a death toll.
- On this same point, Sir Ernest's quoted statement about deaths from fallout (note 127), although in a somewhat ambiguous context, seems to imply that nuclear testing there are the deaths of crew members of a Japanese fishing trawler exposed to fallout from the 1954 Bikini thermonuclear test (Ralph E. Lapp, *The voyage of the Lucky Dragon* (New York: Harper and Row, 1958); *Disarmament campaigns*, No. 2 (May 1980), p. 3). Less definite but suggestive is an increase in leukemia deaths in areas near the US atmospheric nuclear test location in Nevada (Joseph L. Lyon, Melville R. Klauber, John W. Gardner and King S. Udall, "Childhood leukemias associated with fallout from nuclear testing", *New England Journal of Medicine*, 300 (22 February 1979), pp. 397-402; for a general discussion see Lee Torrey, "Disease legacy from Nevada atomic tests", *New scientist*, 84 (1 November 1979), pp. 336-337).
- There have also been reports of cancers and deaths due to the nuclear tests in Australia in the 1950s, especially among servicemen and Aborigines. See the following series of articles by David English and Peter De Iorio in the *Adelaide Advertiser*: "SA atom tests: was cost too high?", 16 April 1980, pp. 8-9; "Signs meant nothing to blacks", 16 April 1980, p. 8; "New reports of cancer. A-vest links", 17 April 1980, pp. 1, 11; op. cit. note 122; "Radioactive cloud 'lost' at midnight", 19 April 1980, p. 12; "Maralinga cancer death toll grows", 19 April 1980, p. 13; "Exposed to cobalt-60 — technician", 23 April 1980, p. 7; anon, "Asio threatened me — A-vest man", 22 April 1980, p. 6; Robert Ball, Peter De Iorio and David English, "Illness, death after a black mist", 3 May 1980, p. 1; Robert Ball, "A 'devil spirit' that didn't go", 3 May 1980, p. 1.
129. While Sir Ernest has made public statements about the lack of hazards from fallout into the 1970s, he has not made similarly vocal statements about the possibility of Australia joining the nuclear weapons club in recent years. This suggests the usefulness of understanding Sir Ernest's views in terms of a high priority on defending the safety of nuclear technology.
130. E. W. Titterton, "World energy needs", *Australian Journal of Science*, 19 (April 1957), pp. 170-172 (p. 171). See also Titterton, op. cit. note 47, p. 202 and Titterton, op. cit. note 102, p. 59.
131. Titterton, op. cit. note 96. See also Sir Ernest Titterton, "Fears of nuclear catastrophe 'hollow and unjustified'", *Canberra Times*, 3 April 1979, pp. 2, 9, where he equates nuclear power "with the very survival of human beings in a Canadian or Russian winter or with the collapse of the Japanese economy and the devastating unemployment which would eventuate unless Japan had access to plentiful energy supplies to turn the wheels of its industry" (p. 9).
132. Titterton, op. cit. note 47, p. 3.
133. Titterton, op. cit. note 47, p. 4; see also pp. 299, 305.
134. Titterton, op. cit. note 106, p. 105.

135. Titterton, *Canberra Times*, op. cit. note 131, p. 2. See also Titterton, op. cit. note 47, pp. 293, 296, 298-299.
136. Titterton, op. cit. note 47, p. 4.
137. An early view was "Discovery must go on; to help guide its use aright is not a purely scientific matter, but the honourable and compelling duty of every good citizen" (Titterton, op. cit. note 47, p. 305). However, the general context of this statement, as discussed below, seems to have been that any well informed citizen would have supported nuclear power.
138. Titterton, *Canberra Times*, op. cit. note 131, p. 9.
139. Sir Ernest Titterton, "Chasing away the bogies of nuclear power", *Sydney Morning Herald*, 31 July 1976, p. 10. See also Titterton, op. cit. note 48, p. 87.
140. Titterton, *Canberra Times*, op. cit. note 74. See also Titterton, *Age*, op. cit. note 107; Titterton, *Sydney Morning Herald*, 13 September 1977, op. cit. note 74; Titterton, op. cit. note 71, p. 30; Titterton, op. cit. note 48, p. 87.
141. E. W. Titterton, letter, *Canberra Times*, 30 March 1979, p. 2.
142. Titterton, op. cit. note 106, p. 106.
143. Titterton, *Age*, op. cit. note 51.
144. Titterton, op. cit. note 141.
145. David Dickson, *Alternative technology and the politics of technical change* (London: Fontana, 1974); Harper and Boyle, op. cit. note 22; Brian Martin, *The bias of science* (Canberra: Society for Social Responsibility in Science (A.C.T.), 1979).
146. This may be verified by for example perusing the debate in the columns of the *Canberra Times*, 1976-1979. For explicit statements of Sir Ernest declining to respond to arguments see Titterton, op. cit. note 141 and E. W. Titterton, letter, *Canberra Times*, 21 August 1979, p. 14.
147. Titterton, op. cit. note 49; also in Titterton, op. cit. note 48, p. 2.
148. *Ibid.*
149. Solange Fernex, "Non-violence triumphant", *Ecologist*, 5 (October 1975), pp. 372-385; Anne Gorygy and friends, *No nukes: everyone's guide to nuclear power* (Boston: South End Press, 1979).
150. Gorygy, op. cit. note 149, pp. 342-343; *Financial Times European energy report*, No. 37 (3 July 1979), p. 9.
151. Gene Sharp, *The politics of nonviolent action* (Boston: Porter Sargent, 1973), p. 543; "Nor, if violence is the opponent's reaction to nonviolent action, does it mean that the nonviolent action created the violence".
152. Harvey Messerman, "Activist murdered in Houston", *Clarnshell Alliance news*, 3 (May-June 1979), pp. 1, 8; Leigh Holloway, "Spanish beat-up", *National Student* (Melbourne), No. 11 (29 October 1979), p. 8; E. San Juan, Jr., "Blueprint for disaster: Westinghouse brings nukes to the Philippines", *Science for the people*, 12 (January/February 1980), pp. 23-26 (p. 24).
153. Titterton, op. cit. note 49; also in Titterton, op. cit. note 48, pp. 2-3, except that "strident" is replaced by "vicious".
154. R. J. Mulvihill, D. R. Arnold, C. E. Bloomquist and B. Epstein, "Analysis of United States power reactor accident probability", PRC R-695 (Los Angeles: Planning Research Corporation, 1965) (unpublished draft from the file "WASH 740 update" Public Documents Room, U.S. Nuclear Regulatory Commission), and "Reactor safety study", U.S. Nuclear Regulatory Commission Report NUREG-75/014 (1975), as cited in Christopher Hohnemser, Roger Kasperson and Robert Kates, "The distrust of nuclear power", *Science*, 196 (1 April 1977), pp. 25-34 (p. 34, notes 36 and 9).
155. Titterton, op. cit. note 131, p. 2: "Further, the proponents point out that 34 nations of the world already have nuclear power systems and six have nuclear-weapon production facilities. But no restrictions on society (police State) have resulted or are even contemplated". The documentation on the effects of nuclear power on civil

- liberties is large (see for example Flood et al., op. cit. note 12), and it would be hard to find another person who denied that nuclear weapons production brings some restrictions in its train.
156. Titterton, op. cit. note 47, p. 5; see also pp. 11, 358.
157. Titterton, *Australian journal of science*, op. cit. note 50, pp. 60-63. See also Titterton, op. cit. note 47, p. 294: "[Scientists] claim no title to superior wisdom or virtue, and, outside their own special field of knowledge, they are just as likely as any other citizen to be misled".
158. Titterton, op. cit. note 49.
159. *Ibid.*
160. *Ibid.*
161. Ranger First Report, op. cit. note 6, p. 5.
162. Sir Ernest Titterton, "The case for nuclear power", *Canberra Times*, 10 November 1976, p. 2; Titterton, *Age*, op. cit. note 51; Titterton, op. cit. note 71, p. 19.
163. Ranger First Report, op. cit. note 6, pp. 5-6.
164. Except as noted all biographical details are from Legge, op. cit. note 42, p. 91: Sir Philip Baxter, "Nuclear power for Australia", *Nat/Dev*, 2 (March 1970), pp. 18-23; Sir Philip Baxter, "Development and the environment: striking a balance", *Developer*, 11 (April 1973), pp. 74-80; J. P. Baxter, "Australia – energy and the future", *Nuclear energy*, "Proceedings of the Royal Australian Chemical Institute", 41 (August 1974), pp. 172-175; Moyai, op. cit. note 4.
165. Gowling, op. cit. note 44, Volume 2. *Policy execution*, pp. 402-423.
166. Michael Symons, "Nuclear power chief runs out of time", *Sydney Morning Herald*, 18 April 1972, p. 3.
167. Moyai, op. cit. note 4, p. 375.
168. Moyai, op. cit. note 4, p. 377 and passim. Besides Moyai's important analysis of the AEEC, see also Allan McKnight, "A French love affair with atoms", *Australian quarterly*, 44 (September 1972), pp. 10-15; Robert Raymond, "How we almost built the bomb but found the sun", *Bulletin*, 99 (7 February 1978), pp. 38-43.
169. J. P. Baxter, "What atomic energy can do for Australia", *New commonwealth*, 16 May 1955, pp. 467-470 (p. 470).
170. J. P. Baxter, "Atomic energy and Australia", *Proceedings of the Royal Australian Chemical Institute*, 24 (November 1957), supplement, pp. 67-75.
171. See for example (Sir) Philip Baxter, "Nuclear reactors for power in Australia", *Australian science teachers journal*, 16 (November 1970), pp. 41-47.
172. Sir Philip Baxter, "Energy in Australia: what of the future?", *Australian director*, 8 (February 1978), pp. 17-20; Sir Philip Baxter, "Some problems in Australian defence", *AIM* (Australian Intelligence Association), 65 (July 1978), pp. 6-10.
173. Baxter, op. cit. note 169, p. 469.
174. J. P. Baxter and D. R. Griffiths, "Nuclear power", in H. G. Raggatt (ed.), *Fuel and power in Australia* (Melbourne: Cheshire, 1969), pp. 91-123 (p. 113).
175. Baxter, op. cit. note 171, p. 45.
176. Anon, "Big chance of global disaster: scientist warns", *Canberra Times*, 26 April 1972, p. 3.
177. Baxter, *Proceedings of the Royal Australian Chemical Institute*, op. cit. note 164, p. 174.
178. Premier Sir Charles Court has announced a desire for a nuclear power plant in Western Australia. Possibilities are also being studied in some other states, especially Victoria.
179. His predictions for overseas developments are not so revealing since they are more clearly based on figures directly taken from other individuals or bodies.
180. Baxter, op. cit. note 171, p. 45.

181. J. P. Baxter, "Environmental pollution and its control", *Atomic energy in Australia*, 14 (April 1971), pp. 2-7 (p. 4).
182. *Ibid.*, p. 5. In later articles Sir Philip admits, but only implicitly, that there is some hazard to life due to the possibility of reactor accidents, when he refers to the results of the 'Reactor safety study' (op. cit. note 154): J. P. Baxter, "Some aspects of the case for nuclear power", *Proceedings of the Royal Australian Chemical Institute*, 43 (January 1976), pp. 16-21.
183. Sir Philip Baxter, "Is nuclear power safe?", Institution of Engineers, Australia. Tasmania Division. *Bulletin*, No. 235 (May 1973), pp. 5-19.
184. Baxter, *Proceedings of the Royal Australian Chemical Institute*, op. cit. note 164, p. 174.
185. Sir Philip Baxter, "The nuclear way is the safe way", *Bulletin*, 98 (24 July 1976), pp. 30-33 (p. 33).
186. Alvin Weinberg and Sir Brian Flowers are examples.
187. Baxter, *Proceedings of the Royal Australian Chemical Institute*, op. cit. note 182, p. 21.
188. See the discussion in sections 2.1 and 2.2, and notes 79, 113 and 114.
189. Baxter, op. cit. note 185, p. 33.
190. Baxter, *Proceedings of the Royal Australian Chemical Institute*, op. cit. note 182, p. 19. See also Baxter, op. cit. note 185; Sir Philip Baxter, "Nuclear joy for Margaret!", *Current affairs bulletin*, 53 (August 1976), pp. 18-23.
191. Michael Symons, "1,000-year guard for nuclear waste", *Sydney Morning Herald*, 14 July 1970, p. 5; Baxter, *Proceedings of the Royal Australian Chemical Institute*, op. cit. note 164; Baxter, op. cit. notes 185, 190, 182.
192. J. P. Baxter, letter, *Search*, 8 (Nov-Dec 1977), p. 392.
193. Anon, "Salt-free water to cities 'in 20 years'", *Canberra Times*, 10 November 1970, p. 11; Baxter, *Proceedings of the Royal Australian Chemical Institute*, op. cit. note 164, p. 175; Baxter, op. cit. note 192.
194. Baxter, *Proceedings of the Royal Australian Chemical Institute*, op. cit. note 164, p. 175.
195. Baxter, *Australian director*, op. cit. note 172, p. 19. See also Baxter, *AIM*, op. cit. note 172; (Sir) Philip Baxter, letter, *Sydney Morning Herald*, 2 July 1979, p. 6; Errol Simper, "Call for nuclear power", *Australian*, 9 July 1979, p. 3.
196. Baxter, op. cit. note 192; Baxter, *AIM*, op. cit. note 172, p. 6.
197. Before he retired from the AEEC in 1972, Sir Philip's public statements about nuclear weapons were circumspect, though in 1968 he was reported as saying in a speech that Australia must be equipped with the most sophisticated and effective weapons devisable, with no type excluded (Robert Mundle, "We must have best weapons, says atom chairman", *Australian*, 20 March 1968, p. 3). More directly, he has been quoted in a speech saying that Australia should develop "a modest nuclear armament – sufficient to make the country prickly" (Geoff Wilkinson, "Future wants to be nuclear", *Mercury* (Hobart), 22 November 1972, p. 3) and has written that "we should develop a nuclear capability" (Sir Philip Baxter, "If nuclear war comes ... *West Australian*, 25 March 1975, p. 7), among many other instances. Sir Philip summarises the evolution of his views thus: "over the years I have initially advocated that we should create the necessary technology and industrial background to enable us to move into a nuclear armament quickly. More recently, things having changed internationally, I'm now the opinion that we should begin actively to create nuclear weapons for the defence of Australia" (Sir Philip Baxter, Ranger Uranium Environmental Inquiry, Transcript of Proceedings, 16 October 1975, pp. 2053-2094 and 21 October 1975, pp. 2099-2220 (p. 2214)).
198. Baxter, op. cit. note 170, p. 71.
199. Baxter, op. cit. note 171, p. 44. See also J. P. Baxter, "Atomic reactors and fuel sources for Australia", *Atomic energy in Australia*, 13 (October 1970), pp. 2-9

- (p. 4): J. P. Baxter, "Some comments on Ann Mozley Moyall's 'The Australian Atomic Energy Commission: a case study in Australian science and government'", *Search*, 6 (Nov-Dec 1975), pp. 456-458 (p. 457).
200. See Moyall, op. cit. note 4, p. 375, who traces Sir Philip's reactor type preferences and notes their links with his views on nuclear weapons, and also gives the quote from Sir Philip. See also S. Encel and Allan McKnight, "Bombs, power stations, and proliferation", *Australian quarterly*, 42 (March 1970), pp. 15-26 (p. 16): "The bomb lobby and the nuclear power lobby were interested in using the production of nuclear explosive as a by-product of the operation of a power reactor as an additional argument for the speed construction of such a reactor." and Allan Barnes, "Scientists had a change of heart", *Age* (Melbourne), 23 February 1970, p. 7 on the reasons for Australia signing the NPT, which according to Barnes was a defeat for the Australian bomb lobby.
201. Moyall, op. cit. note 4, p. 380.
202. Encel and McKnight op. cit. note 200, p. 18; Peter Samuel, "Australia and the nuclear age", *Bulletin*, 93 (12 June 1971), pp. 22-23 (p. 23).
203. Baxter, *Atomic energy in Australia*, op. cit. note 199, p. 5.
204. James V. Ramsden, "Baxter's case for uranium enrichment plant", *Australian Financial Review*, 16 December 1975, p. 12. See also Sir Philip Baxter, "The problems of enriching uranium", *Sun-Herald* (Sydney), 4 August 1974, p. 78; Sir Philip Baxter, "Can uranium contribute to the defence of Australia", *Pacific defence reporter*, 2 (February 1976), pp. 16-17 (p. 17); Sir Philip Baxter, "Uranium enrichment in Australia", *Institution of Mechanical Engineers*, Australian Branch, *News bulletin*, No. 65 (November 1977), pp. 2-5; and Baxter, *AIM*, op. cit. note 172, p. 9 for written statements by Sir Philip.
205. Baxter, op. cit. note 170, p. 70.
206. Anon, "We'll spend \$5000m. on nuclear power by year 2000", *Australian*, 14 July 1969, p. 3.
207. X, "Australian doubts on the treaty", *Quadrant*, 12 (May-June 1968), pp. 30-34.
208. See "Heading for the bomb?", *Nation* (Sydney), No. 272 (12 July 1969), pp. 12-14; also *Nation*, No. 273 (26 July 1969), pp. 4, 17, for evidence that X is Sir Philip. Also see Encel and McKnight, op. cit. note 200, p. 21: "It is reasonable to conclude that [Sir Philip Baxter] is its author". Denials that X is Sir Philip have been made by Peter Coleman, then editor of *Quadrant* (*Nation*, No. 273 (26 July 1969), p. 17) and by Sir Philip himself (as reported by Symons, op. cit. note 166).
209. Symons, op. cit. note 166.
210. X, op. cit. note 207, p. 30.
211. *Ibid.*, p. 31.
212. *Ibid.*, p. 33.
213. *Ibid.*
214. For this view concerning the Australian government's formal reaction to the NPT, see Ian Bellamy, *Australia in the nuclear age: national defence and national development* (Sydney: Sydney University Press, 1972), p. 107. For a critique of the article by X see "Heading for the bomb?", op. cit. note 208.
215. J. P. Baxter, "The international control of fissionable material", *Australian journal of forensic sciences*, 6 (September 1973), pp. 12-31 (p. 30).
216. Baxter, *Pacific defence reporter*, op. cit. note 204, p. 11.
217. Philip Baxter, "Restricting the bomb club", *Quadrant*, 21 (August 1977), pp. 6-7 (p. 7); J. P. Baxter, "Nuclear proliferation: a red herring?", *Quadrant*, 22 (June 1978), pp. 21-23 (p. 22).
218. Baxter, 1978, op. cit. note 217, pp. 21-22.
219. Baxter, op. cit. note 217.
220. Baxter, 1977, op. cit. note 217, p. 6.
221. Sir Philip Baxter, "What if the doomsday men are right?", *West Australian*, 24 March 1975, p. 7.

222. Baxter, *West Australian*, op. cit. note 197.
223. Sir Philip Baxter, "We must stand by to repel boarders", *Herald* (Melbourne), 9 May 1972, p. 4.
224. Gary Daen, "Lifeboat Australia in a storm", *Age* (Melbourne), 26 April 1972, p. 3; Anon, op. cit. note 176; Anon, "I still say beware of doom", *Herald* (Melbourne), 26 April 1972, p. 3. See also Baxter, op. cit. note 223.
225. Mundle, op. cit. note 197; Sir Philip Baxter, "Water seen as key to the development of the centre", *Producers' review*, 61 (November 1971), pp. 5-8.
226. Anon, *Herald*, op. cit. note 224.
227. See for example Baxter, op. cit. note 221.
228. Baxter, 1977, op. cit. note 217, p. 7. See also (Sir) Philip Baxter, letter, *Sydney Morning Herald*, 10 December 1979, p. 6.
229. See for example Anthony Clunies Ross and Peter King, *Australia and nuclear weapons: the case for a non-nuclear region in South East Asia* (Sydney: Sydney University Press, 1966), the arguments in which have never been refuted nor even mentioned by Sir Philip.
230. Baxter, Ranger Inquiry Transcript of Proceedings, op. cit. note 197, pp. 2114, 2115.
231. Baxter, op. cit. note 223.
232. Anon, "5000m face death from disease and war, says atom expert", *Australian*, 27 October 1972, p. 3.
233. Baxter, *Developer*, op. cit. note 164, p. 76.
234. *Ibid.*, p. 78.
235. Baxter, op. cit. note 170, p. 75.
236. Sir Philip Baxter, "Forward", to Nicholas Lindeman, *Japan threat: Australia and New Zealand in the coming world crisis* (Armidale: Nicholas Lindeman, 1976), pp. ii-iv.
237. In a 1979 leaflet put out by the Australian National Alliance, entitled "Introducing the jobs not refugees campaign", Sir Philip is reported as speaking at an Alliance meeting. The Alliance is opposed to acceptance of Asian refugees; it advertises a poster: "Jobs not refugees: white Australia or Asian takeover". It would be ironical in terms of Sir Philip's views if in the event of a global nuclear war the most numerous, powerful and radiation-shattered refugees coming to Australia were from Europe and North America. Yet this seems quite possible in light of the likely damage wrought by a major nuclear war and the availability of ocean transport.
238. Baxter, *AIM*, op. cit. note 172, p. 8 contains the only reference by Sir Philip to Aborigines, to my knowledge. He notes the defence problems posed by large, lightly inhabited areas in the north of Australia, problems "heightened by current policies aimed at making large areas of the territory into aboriginal homelands ... and giving land and minerals to the occupants, a privilege accorded to no other Australians", and sees the situation "open for exploitation by radical part-aboriginals from the large so [u]thern cities who see the opportunity for a power base and a black state." Though no more than a statement of views, without argumentation or factual backing, the link with his views about the anti-nuclear conspiracy discussed in section 3.3 is clear.
239. Anon, "Japanese 'could take uranium'", *Canberra Times*, 29 March 1976, p. 1.
240. Sir Philip Baxter, "Forensic aspects of pollution by petrol engines and the power stations. Are there solutions?", *Australian journal of forensic sciences*, 5 (September 1972), pp. 10-14 (p. 11).
241. Baxter, *Developer*, op. cit. note 164, p. 77.
242. J. P. Baxter, letter, *Proceedings of the Royal Australian Chemical Institute*, 43 (March 1976), p. 95.
243. Sir Philip Baxter, "The parable of the foolish passengers", *Mining review* (January 1977), p. 6; a closely similar version is Sir Philip Baxter, "Parable of the unwise passengers", *Australian*, 18 February 1977, p. 11.

244. Anon, "And this is what it means ...", *Australian*, 18 February 1977, p. 11.
245. Brian Martin, letter, *Canberra Times*, 21 July 1979, p. 2.
246. The values implicit in technical decisions have been spelled out many times, for example in Martin, op. cit. note 145 and Lovins, op. cit. note 84. The inadequacy of professional integrity alone in making experts serve the public interest is documented in Hipel, *Advice and dissent: scientists in the political arena* (New York: Basic Books, 1974). Finally, D. C. Sarns and I. S. Falconer, "Nuclear energy – attitudes survey", *Australian physicist*, 16 (May 1979), pp. 58-67 find that the distribution of attitudes to the mining of uranium and to nuclear power follows generally the same pattern among physicists as in the general population. However, they also find among nuclear physicists, in particular those with reactor experience, a greater proportion who are supportive of nuclear power.
247. Baxter, *Proceedings of the Royal Australian Chemical Institute*, op. cit. note 182, p. 20.
248. Each of the three reprocessing plants in the US is out of operation due to safety, technological and economic problems. On the problems of plutonium see Philip Baxter, letter, *Medical Journal of Australia* (26 November 1977: 2), p. 753 and the following replies: John Melov, letter, *Medical Journal of Australia* (14 January 1978: 7), pp. 40-41; Robert Peers, letter, *Medical Journal of Australia* (28 January 1978: 7), pp. 102-103; Mark Diesendorf, letter, *Medical Journal of Australia* (11 February 1978: 7), pp. 162-163.
249. Compare Baxter, *Proceedings of the Royal Australian Chemical Institute*, op. cit. note 182, which refers to three studies within its text (without bibliographical details) and has no footnotes, with the accompanying anti-nuclear article by F. P. J. Robotham, "Uranium and nuclear power – some unsolved problems", *Proceedings of the Royal Australian Chemical Institute*, 43 (January 1976), pp. 22-25, which has 14 footnotes.
- See also J. P. Baxter, "Health and radioactive pollution", *Medical Journal of Australia* (16 August 1975: 2), pp. 267-274 with two references listed, in a journal most of whose articles are highly documented. For documentation of pro-nuclear articles see the journal *Atomic energy in Australia*, Sir Philip's articles in this journal are very sparsely documented compared to almost all others.
250. Baxter, op. cit. note 183, p. 11; see also Errol Simper, "Australia's uranium will have to be mined, says Sir Philip", *Canberra Times*, 6 March 1976, p. 2.
251. Sir Philip Baxter, "What is research worth?", *Current affairs bulletin*, 1 April 1973, pp. 340-346 (p. 343); see also Baxter, *Developer*, op. cit. note 164.
252. J. P. Baxter, letter, *Search*, 9 (April 1978), p. 112.
253. Moyai, op. cit. note 4, p. 370.
254. Baxter, *Search*, op. cit. note 199, p. 458.
255. This may not be the way Sir Philip perceives his stance. He has said "I'm very much a democrat ... I believe in freedom, freedom of speech and freedom of every kind" (Sir Philip Baxter, "The case for uranium mining", *Loft's wife* (Students Representative Council, Monash University), 18 (23 June 1978), pp. 4-5 (p. 4)).
256. Barrington Moore, Jr., *Injustice: the social bases of obedience and revolt* (London: Macmillan, 1978), p. 443.
257. Sir Philip Baxter, "Forensic problems in an overcrowded world", *Australian journal of forensic sciences*, 7 (September 1974), pp. 11-16 (p. 13).
258. *Ibid.*, p. 16.
259. Baxter, op. cit. note 181, p. 3.
260. Baxter, *Developer*, op. cit. note 164, p. 78.
261. Baxter, *Current affairs bulletin*, op. cit. note 190, p. 19.
262. Baxter, *Proceedings of the Royal Australian Chemical Institute*, op. cit. note 182, p. 16.
263. J. P. Baxter, letter, *Search*, 10 (Jan-Feb 1979), p. 12.

264. J. P. Baxter, "Is the anti-nuclear campaign an international conspiracy?", *Quadrant*, 23 (June 1979), pp. 10-12; J. P. Baxter, letter, *Canberra Times*, 12 September 1979, p. 2; Baxter, op. cit. note 263.
265. Baxter, *Current affairs bulletin*, op. cit. note 190, p. 23.
266. (Dr) Mark Diesendorf, letter, *Sydney Morning Herald*, 24 October 1977, p. 6.
267. (Sir) Philip Baxter, letter, *Sydney Morning Herald*, 24 October 1977, p. 6.
268. See for example Baxter, op. cit. note 263; "In Australia we have received a procession of American pseudo-scientific propagandists, with the odd one or two from England. They tour Australia and pour poison into the ears of the gullible". See also J. P. Baxter, letter, *Canberra Times*, 27 June 1979, p. 16; "Mr Diesendorf presumably considers himself a professional, though I am not clear what he professes ... People who are tempted to swallow the nonsense he peddles ...".
269. Most notable are Associate Professor R. B. Temple, Department of Physical Chemistry, Sydney University, formerly of the AAECC (see for example Richard Temple, "The large-scale use of nuclear power: a Faustian bargain", *Current affairs bulletin*, 52 (May 1976), pp. 4-17; Temple, op. cit. note 1) and F. P. Robotham, Radiation Protection Officer, University of Melbourne, formerly of the AAECC (see Robotham, op. cit. note 249; Robotham, op. cit. note 1).
270. Most of the finance for the anti-nuclear campaign in Australia has come from sales of books, badges and stickers and from small donations. The greatest strength of the campaign has been the many people who have volunteered to work for it.
271. Gyorgy et al., op. cit. note 149.
272. Roberts, *Arena*, op. cit. note 19 can be interpreted as a plea to the left to actively oppose nuclear power. A typical marxist attack on environmentalists is Melanie Beresford, "Doomsayers and eco-nuts: a critique of the ecology movement", *Politics*, 12 (May 1977), pp. 98-106.
273. Lovins, *Soft energy paths*, op. cit. note 21, p. 53; Anon, "Russia worried over N safety", *Age* (Melbourne), 15 October 1979, p. 8; Satter, op. cit. note 81.
274. On this point, the hushing up in the USSR of a 1957 nuclear accident in the Urals (Zhores Medvedev, *Nuclear disaster in the Urals* (London: Angus and Robertson, 1979)) is relevant. That it was also unpublished in the west may say something about the common interests of the nuclear establishments in countries with widely different political systems.
275. A good treatment is in Gyorgy et al., op. cit. note 149, pp. 355-360. See also Wendy Varney, "Soviet nuclear power", *Time and energy* (Sydney), No. 7 (1978), p. 17. Other factors to take into account in explaining the Soviet nuclear programme are its smallness (several times smaller than the US programme), the USSR's continued role in supplying large amounts of enriched uranium for nuclear power plants in western Europe and the relative lack of safety features in Soviet reactors which severely restricts their export potential. Such factors suggest that western nuclear power programmes have a much larger impact on Soviet nuclear power than vice versa.
276. David Pearce, Geoff Beuret and Lynne Edwards, "Opposition to civilian nuclear power and the role of the public inquiry", in Uranium Institute, *Uranium supply and demand* (London: Mining Journal Books, 1978), pp. 209-230 (p. 213).
277. Since this is a summary table, the entries necessarily simplify the full scope of the arguments and claims of Sir Ernest and of Sir Philip. 'Denial' should be taken to mean that the bulk of the treatment of the area indicated is based on stating that the problems raised by critics of nuclear power do not exist, with little actual grappling with the arguments of the opponents. 'Not mentioned' means that the area is never, or only very cursorily and seldom, mentioned as one of concern. In other cases where a more elaborated case is presented the basic points made are listed. Often, of course, the different types of response are not greatly different in practice.
278. Sir Ernest's and Sir Philip's views on environmental hazards and the soft energy path were discussed in sections 2.1 and 3.1 respectively and their views on proliferation in sections 2.2 and 3.2.

279. Sir Ernest and Sir Philip each say that the probability that terrorists might acquire nuclear weapons by using materials from nuclear power facilities is negligible. (For reasons of space their views on this have not been examined in this study.) As for restrictions on civil liberties and democratic decision-making posed by the hazardous nature of nuclear technology, by terrorist and criminal threats and by the centralisation of political and economic control in a nuclear society, Sir Ernest denies that such problems exist (see op. cit. note 185) in the one reference to this area of which I am aware. Sir Philip says that laws to prevent nuclear terrorism "have no impact whatsoever on law-abiding citizens who see them as being for their protection" and that the nuclear industry "has been around for more than 30 years and I have not noticed any impact on the civil liberties of respectable citizens. Those who may not be so described may have different feelings" (J. P. Baxter, letter, *Engineers Australia* (16 November 1979), p. 3). This is his only reference to this area of which I am aware.
280. As in the case of terrorism, the views of Sir Ernest and of Sir Philip concerning the economics of nuclear power and other energy sources and options are not examined here for reasons of space. Suffice it to say that each of them, especially Sir Ernest, claims that nuclear power is cheaper than other energy sources and options. As for employment, while each mentions the jobs provided by uranium mining and mentions the essential role of energy production in sustaining industry and the jobs in it, neither has compared the job-creating potential of investments in nuclear power and uranium mining with that of investments in other enterprises.
281. Sir Ernest and Sir Philip almost totally avoid the Aboriginal issue. Sir Ernest in one brief mention says that "These matters, however, are local and social and have nothing to do with the safety of mining or nuclear power", that "The Aboriginal community has full citizenship rights, neither more nor less than other Australians" and that uranium mining will bring changes "but this is not new" for Aborigines (Titterton, op. cit. note 48, p. 109; see also Titterton, *Camberra Times*, op. cit. note 131, p. 2). A rare mention of Aborigines by Sir Philip has been noted previously (op. cit. note 238). It is advantageous for the pro-uranium case to mention the Aboriginal situation as little as possible, since there is virtually nothing positive that can be said for uranium mining so far as the Aborigines are concerned (Fanger, Second Report, op. cit. note 6).
282. The same conclusion has been reached for Europe by Groupe de Bellerive, "The nuclear power debate in Western Europe", *Bulletin of the atomic scientists*, 35 (September 1979), pp. 11-12.
283. Gilpin, op. cit. note 41; Leon N. Lindberg, "Comparing energy policies: political constraints and the energy syndrome", in Leon N. Lindberg (ed.), *The energy syndrome: comparing national responses to the energy crisis* (Lexington: D. C. Heath, 1977), pp. 325-356 (especially pp. 344-345); Cecil H. Uyebara, "Scientific advice and the nuclear test ban treaty", in Sanford A. Lakoff (ed.), *Knowledge and power: essays on science and government* (New York: Free Press, 1966), pp. 112-161; Sanford A. Lakoff, "Scientists, technologists and political power", in Ian Spielgel-Rosing and Derek de Solia Price (eds.), *Science, technology and society: a cross-disciplinary perspective* (London: Sage, 1977), pp. 355-391; Eugene B. Skolnikoff, *Science, technology, and American foreign policy* (Cambridge, Massachusetts: MIT Press, 1967); Harold Kagan Jacobson and Eric Stein, *Diplomats, scientists, and politicians: the United States and the nuclear test ban negotiations* (Ann Arbor: University of Michigan Press, 1966).
284. Boffey, op. cit. note 31; Primack and von Hippel, op. cit. note 246; Samuel S. Epstein, *The politics of cancer* (San Francisco: Sierra Club Books, 1978).
285. Diesendorf, op. cit. note 116.
286. Steinhart, op. cit. note 33, p. 507.
287. *Ibid.*, p. 512.
288. Margali Sarfatti Larson, *The rise of professionalism: a sociological analysis* (Berkeley: University of California Press, 1977).

289. Langdon Winner, *Autonomous technology: technicians-out-of-control as a theme in political thought* (Cambridge, Massachusetts: MIT Press, 1977), p. 170.
290. John D. Steinbruner, *The cybernetic theory of decision: new dimensions of political analysis* (Princeton: Princeton University Press, 1974), pp. 120-121. Gilpin, op. cit. note 41, pp. 265, 300-301 describes how scientists with different political opinions come to believe that opponents are distorting the facts.
291. Pearce et al., op. cit. note 276, p. 214: "Descriptions of the opposition [to nuclear power] as 'irrational or politically motivated' or 'fanatics' merely reflect the ignorance of those making the remarks". See also David Pearce, "The nuclear debate is about values", *Nature*, 274 (20 July 1978), p. 200.
292. See Martin, op. cit. note 145, chapter 8 for an example illustrating this.
293. Two of the best general sources are Boffey, op. cit. note 31 and Primack and von Hippel, op. cit. note 246. Gilpin, op. cit. note 41, p. 279 notes that the confrontation of scientists on the issues of nuclear weapons made their non-technical assumptions obvious.
294. See for example David Robbins and Ron Johnston, "The role of cognitive and occupational differentiation in scientific controversies", *Social studies of science*, 6 (1976), pp. 349-368 on the "role of cognitive and occupational differentiation" in the controversy over levels of environmental lead; Jonathan Harwood, "The race-intelligence controversy: a sociological approach. I — professional factors", *Social studies of science*, 6 (1976), pp. 369-394 on the role of professional backgrounds and disciplinary allegiances in the race-intelligence controversy; and Edwin T. Layton, Jr., *The revolt of the engineers: social responsibility and the American engineering profession* (Cleveland: Case Western Reserve University Press, 1971) on the ideology of engineering.
295. Allan Mazur, "Disputes between experts", *Minerva*, 11 (1973), pp. 243-262. See also Boffey, op. cit. note 31, chapter 5 on the issue of radioactive waste disposal.
296. Vincent Heath Whitney, "Resistance to innovation: the case of atomic power", *American Journal of sociology*, 56 (1950), pp. 247-254; Dorothy Nelkin, *Nuclear power and its critics: the Cayuga Lake controversy* (Ithaca: Cornell University Press, 1971); Steven Ebbin and Rabbahel Kasper, *Citizen groups and the nuclear power controversy: uses of scientific and technological information* (Cambridge, Massachusetts: MIT Press, 1974); John Surrey and Charlotte Huggett, "Opposition to nuclear power: a review of international experience", *Energy policy*, 4 (December 1976), pp. 286-307; Laura Lewis and David Morell, "Nuclear power and its opponents: a New Jersey case study", Princeton University Center for Environmental Studies, May 1977; Pearce et al., op. cit. note 276.
297. H. Peter Metzger, *The atomic establishment* (New York: Simon and Schuster, 1972).
298. Richard S. Lewis, *The nuclear power rebellion: citizens vs. the atomic industrial establishment* (New York: Viking, 1972); Gyorgy et al., op. cit. note 149, chapters 4 and 5.
299. Bayard Stockton and Peter Janke, "Nuclear power: protest and violence", *Conflict studies*, No. 102 (December 1978).
300. Diesendorf, op. cit. note 116; Charles Kerr, "Perception of risk in the nuclear debate", in F. W. G. White (ed.), *Scientific advances and community risk* (Cambridge: Australian Academy of Science, 1979), pp. 46-70; Moyal, op. cit. note 4.
301. Some of the prominent nuclear advocates in the English-speaking scientific community are Hans Bethe, Petr Beckmann, Bernard Cohen, Sir Fred Hoyle, Ralph Lapp, Edward Teller and Alvin Weinberg. One important point worth noting in evaluating their arguments is their stance on nuclear weapons. Gilpin, op. cit. note 41, especially pp. 279-297 classifies US scientists into the control school, the finite containment school and the infinite containment school on the basis of their views on nuclear weapons. Sir Ernest and Sir Philip, as documented herein, belong in the last of these categories.

302. David L. Sills, "The environmental movement and its critics", *Human ecology*, 3 (1975), pp. 1-41 surveys the arguments of critics of the environmental movement. There are numerous discussions and criticisms of the direction of the environmental movement from within, including Brian Martin, "Soft energy hard politics", *Undercurrents*, No. 27 (1978), pp. 10-13.
303. Titterton, op. cit. note 48, p. 80.
304. Sherman A. Minton, Jr., "Snakebite", *Scientific American*, 196 (January 1959), pp. 114-122 (p. 115).
305. American Nuclear Society, *Nuclear power and the environment: questions and answers* (Hinsdale, Illinois: AMS, 1976), p. 53.
306. J. Martin Brown, "Health, safety and social issues of nuclear power and the nuclear initiative", in W. C. Reynolds (ed.), *The California nuclear initiative: analysis and discussion of the issues* (Stanford: Institute for Energy Studies, Stanford University, 1976), pp. 127-201 (p. 150).

Sources for bold face quotes

- Page 23: Titterton, op. cit. note 48, p. 2.
- Page 27: *Ibid.*, p. 87.
- Page 30: Titterton, op. cit. note 95, p. 9.
- Page 31: Titterton, op. cit. note 99.
- Page 36: Titterton, op. cit. note 47, p. 294.
- Page 42: Baxter, op. cit. note 170, p. 75.
- Page 46: J. P. Baxter, "Atomic power in industry", in *Atomic power in Australia* (Sydney: New South Wales University of Technology, 1954), pp. 47-55 (p. 50); J. P. Baxter, letter, *Canberra Times*, 12 December 1979, p. 40.
- Page 47: Baxter, *Pacific defence reporter*, op. cit. note 204, p. 17.
- Page 51: Baxter, op. cit. note 223.
- Page 54: Baxter, *Search*, op. cit. note 199, p. 458.
- Page 56: *Ibid.*
- Page 58: Baxter, *Proceedings of the Royal Australian Chemical Institute*, op. cit. note 182, p. 16; Baxter, *Canberra Times*, op. cit. note 264.

Sir Ernest Titterton and Sir Philip Baxter have been the most prolific public advocates of nuclear power in Australia. *Nuclear Knights* is a careful study of the pro-nuclear views of Sir Ernest and of Sir Philip. Special emphasis is put on the assumptions underlying their views and on the links between their views and their professional positions. *Nuclear Knights* shows in detail why it is not always safe to trust the experts.

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